FINAL
RECORD OF DECISION

OPERABLE UNIT 5
NAVAL AIR STATION
WHIDBEY ISLAND
OAK HARBOR, WASHINGTON

Prepared by
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Seattle, Washington

Prepared for
Engineering Field Activity, Northwest
Southwest Division, Naval Facilities Engineering Command
Poulsbo, Washington

May 1996

Signed 7-10-96

DECLARATION OF THE RECORD OF DECISION

SITE NAME AND ADDRESS

Naval Air Station Whidbey Island, Ault Field
Operable Unit 5, Areas 1, 52, and 31
Oak Harbor, Washington

STATEMENT OF PURPOSE

This decision document presents the final remedial action for Operable Unit (OU) 5, one of four operable units at the Naval Air Station (NAS) Whidbey Island, Ault Field, Superfund site near Oak Harbor, Washington. The selected remedy in this decision document was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the Administrative Record for OU 5.

The U.S. Navy (Navy) is the lead agency for this decision. The U.S. Environmental Protection Agency (EPA) has approved of this decision. The State of Washington concurs with the selected remedy.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from OU 5, if not addressed by implementing the response action selected in this Record of Decision (ROD), may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE SELECTED REMEDIES

OU 5 originally consisted of Area 1 (the Beach Landfill) and Area 52 (the Jet Engine Test Cell). Area 31 (the Former Runway Fire School) was studied as part of OU 3. Because of the need for further evaluation and to avoid delaying cleanup of the other site at OU 3, Area 31 was moved from OU 3 and incorporated into OU 5.

There are no human health risks associated with Area 1. The selected remedy at Area 1 addresses potential ecological risks. Groundwater at Area 1, although not a potential source of drinking water, discharges to marine water. The groundwater was found to contain cyanide at concentrations that could adversely affect marine life. However, biological surveys of the beach and intertidal zone found no apparent ill effects to biota from Area 1. The selected remedy includes sampling in the intertidal zone and groundwater monitoring, along with biological surveys of the beach, to determine if ecological risks exist and if further actions are needed to protect marine life. The selected remedy also includes use restrictions to prevent installation of drinking water wells or development that could cause human or environmental exposure to landfill contents.

There are no human health risks associated with Area 52. The selected remedy at Area 52 addresses potential ecological risks posed by floating petroleum product on the groundwater. Groundwater at Area 52, although not a potential source of drinking water, discharges to marine water. The objective at Area 52 is to prevent the petroleum from discharging to marine water, but not to clean up groundwater to drinking water standards. The petroleum will be skimmed from the groundwater and treated or recycled off site. Groundwater monitoring will be conducted to evaluate the effectiveness of the remedy. The selected remedy also includes use restrictions to prevent installation of drinking water wells and to limit development that could expose humans to petroleum.

The selected remedy at Area 31 addresses exceedances of drinking water standards and potential future human health risks posed by chemicals found in groundwater. The sources of these chemicals are an oil/water separator and associated petroleum-contaminated soils and floating petroleum product on the groundwater. The objective at Area 31 is to remove enough of these sources so that groundwater contamination does not spread, but not actively clean up groundwater to drinking water standards. The oil/water separator will be excavated and disposed of, and the petroleum will be skimmed from the groundwater and treated or recycled off site. The selected remedy includes oil skimming and bioventing; bioventing is intended as a contingent measure. Groundwater monitoring will be conducted. The selected remedy also includes use restrictions to limit development and prevent installation of drinking water wells.

The selected remedies for both Areas 31 and 52 rely on natural attenuation to achieve groundwater cleanup levels over the long term.

STATUTORY DETERMINATIONS

The selected remedies are protective of human health and the environment, are in compliance with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, and are cost-effective. The remedies utilize permanent solutions and alternative treatment (or resource recovery) technologies to the maximum extent practicable.

For Areas 31 and 52, the remedies satisfy the statutory preference for treatment that reduces toxicity, mobility, or volume as a principal element. However, for Area 1, because treatment of the principal threats from the site was not found to be practicable, the remedy does not satisfy the statutory preference for treatment. At each site, the remedies will result in hazardous substances, pollutants, or contaminants remaining on site. Therefore, each remedial action will be reviewed no less than every 5 years to ensure that human health and the environment are being protected.

Signature sheet for the foregoing Naval Air Station Whidbey Island, Ault Field, Operable Unit 5, final remedial action, Record of Decision, between the U.S. Navy and the U.S. Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Chuck Clarke

7/10/96

Chuck Clarke
Regional Administrator, Region 10
U.S. Environmental Protection Agency

Date

Signature sheet for the foregoing Naval Air Station Whidbey Island, Ault Field, Operable Unit 5, final remedial action, Record of Decision, between the U.S. Navy and the U.S. Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

L J Munns
Captain L.J. Munns
Commanding Officer, Naval Air Station Whidbey Island
U.S. Navy

30 May 96
Date

Signature sheet for the foregoing Naval Air Station Whidbey Island, Ault Field, Operable Unit 5, final remedial action, Record of Decision, between the U.S. Navy and the U.S. Environmental Protection Agency, with concurrence by the Washington State Department of Ecology.

Emily H. Ray, Acting for
Mary E. Burg
Program Manager, Toxics Cleanup Program
Washington State Department of Ecology

June 28, 1996
Date

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ABBREVIATIONS AND ACRONYMS

ACF	water to air conversion factor
ARAR	applicable or relevant and appropriate requirement
avgas	aviation gasoline
AWQC	ambient water quality criteria
BAF	bioaccumulation factor
BJP	best professional judgment
BTEX	benzene, toluene, ethylbenzene, and xylenes
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
COC	chemical of concern
COPC	chemical of potential concern
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CR	cancer risk
CSF	cancer slope factor
CWA	Clean Water Act
DC	dermal contact
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethene
DoD	U.S. Department of Defense
DDT	Dichlorodiphenyltrichloroethane
Ecology	Washington State Department of Ecology
EFA NW	Engineering Field Activity, Northwest
EPA	U. S. Environmental Protection Agency
EqP	equilibrium partitioning
ER-L	effects range-low
FED MCL	Federal Safe Drinking Water Act, Maximum Contaminant Levels
FFA	federal facility agreement
HEAST	EPA's Health Effects Assessment Summary Tables
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient

ABBREVIATIONS AND ACRONYMS (Continued)

ING	ingestion
INH	inhalation
IR	Installation Restoration
IRIS	EPA's Integrated Risk Information System
JP-5	jet petroleum fuel #5
LOEL	lowest-observed effects level
MCL	maximum contaminant level
MCLG	maximum contaminant level goals
MFS	Minimum Functional Standards
msl	mean sea level
MTCA	Model Toxics Control Act
MW	monitoring well
NA	not applicable
NACIP	Navy Assessment and Control of Installation Pollutants
NAS	Naval Air Station
NAVFACENGCOM	Naval Facilities Engineering Command
NAVY	U.S. Navy
NC	not calculated
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
ND	not detected
NE	not evaluated
NPL	National Priorities List
O&M	operating and maintenance
OU	operable unit
OWS	oil/water separator
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
RAB	Restoration Advisory Board
RAO	remedial action objective
RBSC	risk-based screening concentration
RCW	Revised Codes of Washington
RfD	reference dose
RI/FS	remedial investigation/feasibility study
RME	reasonable maximum exposure
ROD	record of decision
SARA	Superfund Amendments and Reauthorization Act of 1986

ABBREVIATIONS AND ACRONYMS (Continued)

SQS	sediment quality standards
SVOC	semivolatile organic compound
TAL	target analyte list
TBC	to be considered
TCDD	tetrachlorodibenzo-p-dioxin
TCL	target compound list
TCLP	toxicity characteristics leaching procedure
TEC	toxicity equivalency concentration
TPH	total petroleum hydrocarbons
TRC	Technical Review Committee
TRV	toxicity reference value
UCL	upper confidence limit
USC	United States Code
UST	underground storage tank
VOC	volatile organic compounds
WAC	Washington Administrative Code
WA FWQS	Washington Water Pollution Control Act, Fresh Water Quality Standards
WA MCL	Washington State Maximum Contaminant Levels
WA MWQS	Washington Water Pollution Control Act, Marine Water Quality Standards
95UCL	95 percent upper confidence limit

DECISION SUMMARY

1.0 INTRODUCTION

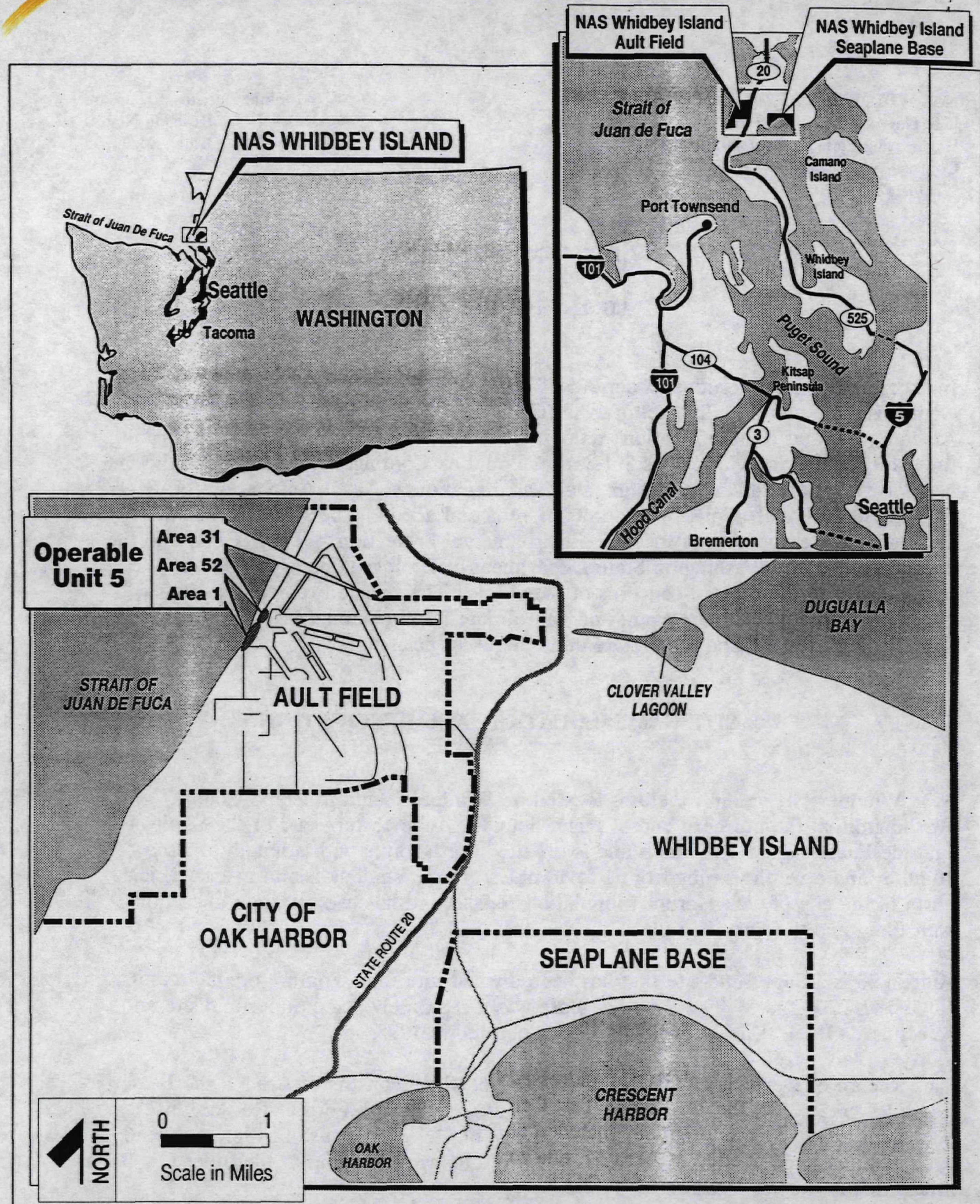
In accordance with Executive Order 12580, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the U.S. Navy (Navy) is addressing environmental contamination at Naval Air Station (NAS) Whidbey Island, Ault Field, by undertaking remedial action. The selected remedial actions have the approval of the U.S. Environmental Protection Agency (EPA) and the concurrence of the Washington State Department of Ecology (Ecology) and are responsive to the expressed concerns of the public. The selected remedial actions will comply with applicable or relevant and appropriate requirements (ARARs) promulgated by Ecology, the EPA, and other state and federal agencies.

2.0 SITE NAME, LOCATION, AND DESCRIPTION

NAS Whidbey Island, Ault Field, is located on Whidbey Island in Island County, Washington, at the northern end of Puget Sound and the eastern end of the Strait of Juan de Fuca (Figure 1). The island is oriented north-south, with a length of almost 40 miles and a width varying from 1 to 10 miles. NAS Whidbey Island is located just north of the city of Oak Harbor (population 14,000) and has two separate operations: Ault Field and the Seaplane Base.

Ault Field is a Superfund site that has been divided into four separate operable units (OUs): 1, 2, 3, and 5. The Seaplane Base was a separately listed Superfund site and constituted OU 4. The Seaplane Base was delisted in 1995.

This Record of Decision (ROD) addresses OU 5, which consists of Area 1, the Beach Landfill; Area 52, the Jet Engine Test Cell; and Area 31, the Former Runway Fire School. Area 31 was originally included as part of OU 3. Because further study and evaluation were needed at Area 31, and to avoid delaying cleanup at the other OU 3 area, Area 31 was transferred to OU 5.



CLEAN COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY	Figure 1 NAS Whidbey Island Location Map	CTO 0162 Operable Unit 5 NAS Whidbey Island, WA ROD

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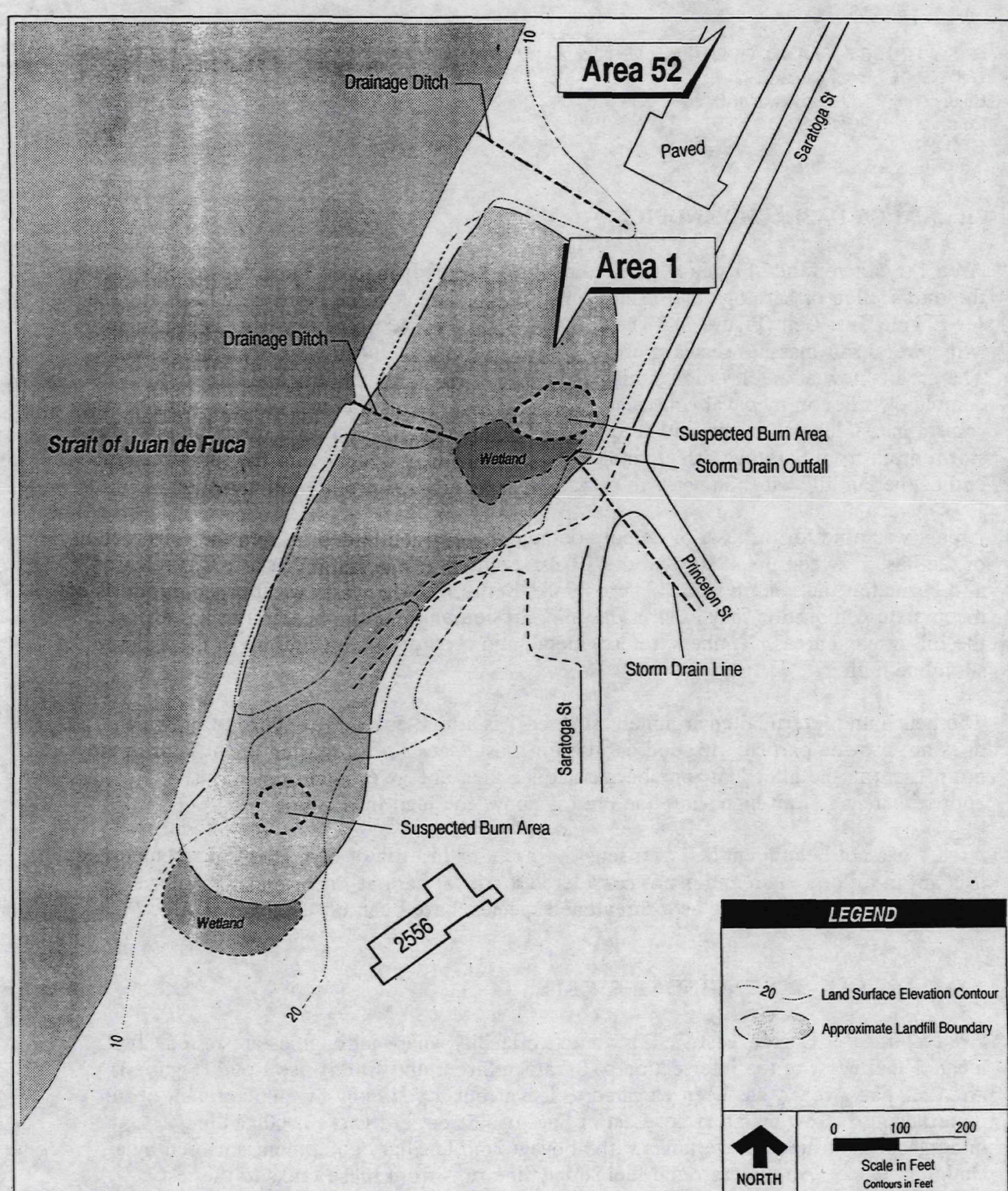

CLEAN COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY	**Figure 2** **Area 1, Operable Unit 5** **Beach Landfill**	CTO 0162 Operable Unit 5 NAS Whidbey Island, WA ROD

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2.1 AREA 1—BEACH LANDFILL

Area 1, a 6-acre landfill running parallel to the Strait of Juan de Fuca, is located west of the intersection of Saratoga and Princeton Streets, between the Norwester Club and the Jet Engine Test Cell (Figure 2). The site originally consisted of low-lying beach ridges with several salt marshes seaward of the historical bluff located west of Saratoga Street. The area is now at an elevation similar to that of the former bluffs and has been completely filled in by naval construction activities. Two small marsh areas remain: the central marsh located in the middle of the landfill, which serves as a retention pond for a storm drain from Saratoga Street, and the southern marsh located at the southwestern end of the landfill, which appears to remain at its original pre-landfill elevation.

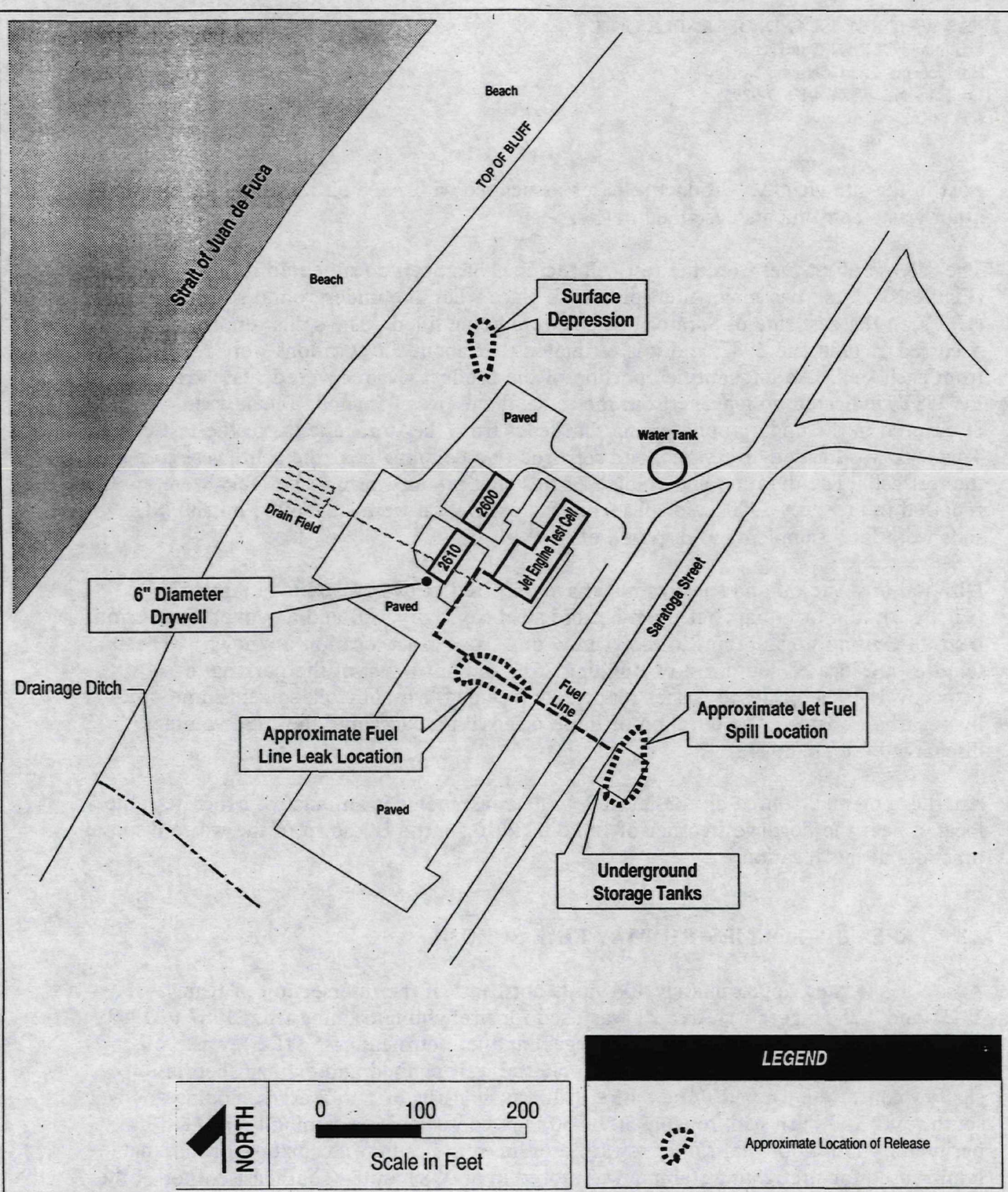
Area 1 was used for disposal of demolition and construction debris from the construction of the base between the 1940s and the 1970s. Some of the station's waste was released and burned at the landfill from 1945 to 1958. Because the waste was burned, products of incomplete combustion may exist in the fill. Erosion along the beachfront has exposed the fill in many areas. Timbers, refuse, metal, and concrete are present in the exposed shoreline bluff.

The beach and intertidal environment at Area 1 is a high-energy environment, which does not provide particularly good habitat for most species of marine life. Shellfish are not present in the intertidal zone because it is a high-energy environment. The approximately 10-foot-high shoreline bluff is above the high tide line.

Area 1 has not been identified as a sensitive area for historic or archeological resources; it is not in a flood plain and is not considered a critical habitat for endangered species. However, bald eagles, listed as a threatened species, have been observed at Area 1.

2.2 AREA 52—JET ENGINE TEST CELL

Area 52, the Jet Engine Test Cell, is an active facility where jet engines are tested. It is located southwest of the intersection of Saratoga Street and Enterprise Road (Figure 3). Area 52, like Area 1, has been elevated to its current topography by emplacement of fill materials into a low marsh area. East of Saratoga Street are two 10,000-gallon underground jet fuel storage tanks with aboveground ancillary equipment enclosed by a chainlink fence. An underground fuel supply line runs from these tanks to the test facilities. Several buried utilities, a large storm drain, and other underground pipelines



CLEAN COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY	**Figure 3** **Area 52, Operable Unit 5** **Jet Engine Test Cell**	CTO 0162 Operable Unit 5 NAS Whidbey Island, WA ROD

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exist in the site vicinity. Product releases associated with Area 52 include jet fuel and other waste constituents described below.

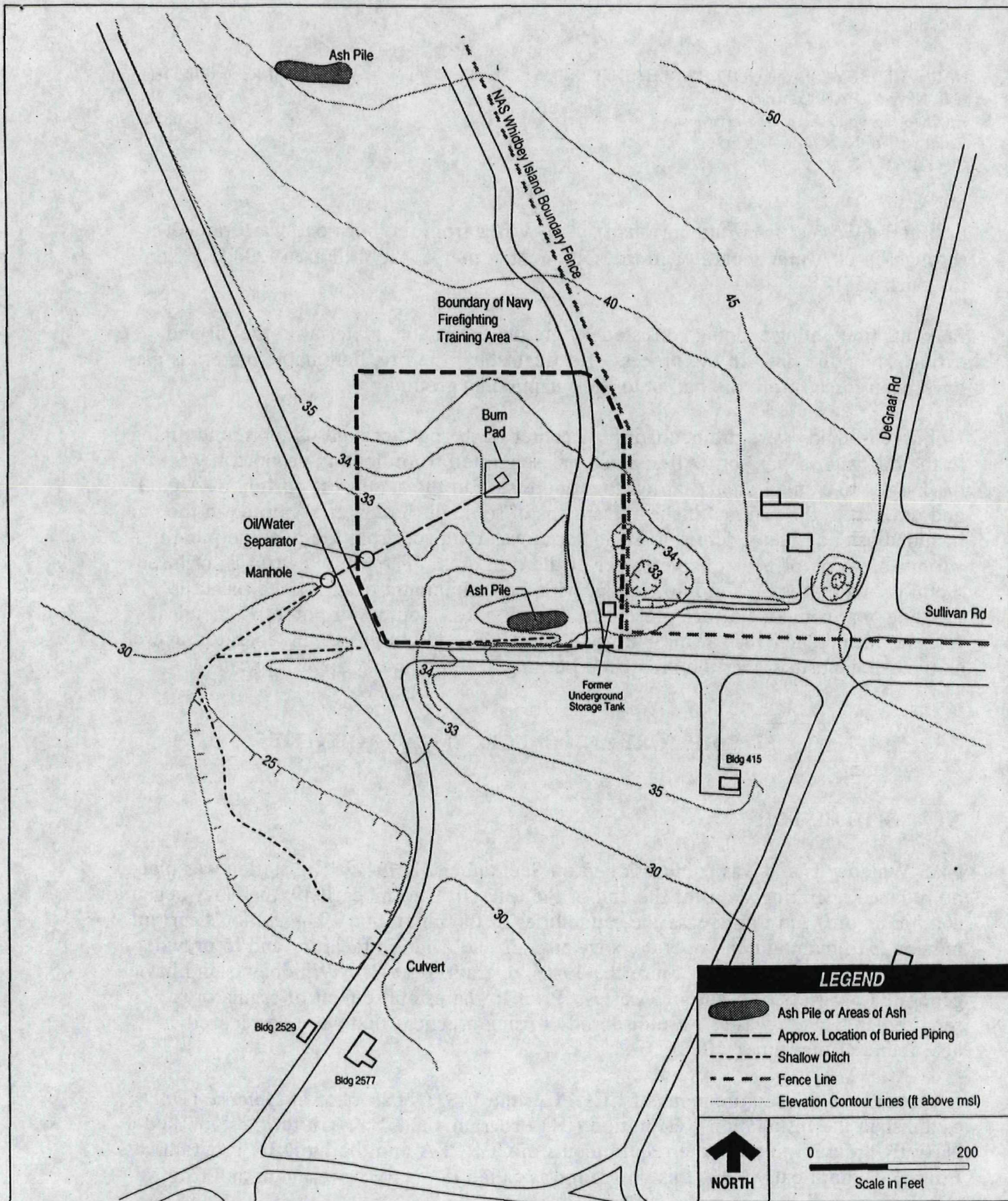
The release of jet fuel from the test cell facilities has been documented in two locations (Figure 3). First, two major fuel spills took place when the underground storage tanks (USTs)on the east side of Saratoga Street were being filled. The spills reportedly occurred in 1986 and 1987, and it is estimated that about 1,200 gallons were released from each spill. An unquantified portion of the product was recovered. Leak testing of the USTs indicated no leakage from the tanks themselves. Second, a leak was discovered in the underground piping that leads from the storage tanks to the test cell. This leak was located, excavated, and repaired at a coupling near the southwest corner of the test cell. The duration and volume of this leak are unknown. The leaks were repaired in the early 1990s and soils from the excavation were stockpiled on site. The soils were later sampled and disposed of properly.

Disposal of waste oil and solvents may have occurred at two locations in Area 52 (Figure 3): a 6-inch-diameter open-bottom steel-cased dry well and a sunken depression near an existing storm drain (in the vicinity of MW-4, exact location unknown). These features are located southwest of Building 2610 and northwest of the parking lot, respectively. The disposed wastes reportedly included hydraulic oil, solvents, and other hydrocarbon wastes. The duration of these disposal practices and the total volumes discharged are unknown.

Another potential source of non-jet fuel waste constituents is an inactive concrete sump located near the northwest corner of Building 2610. Little is known of the waste disposal practices at this location.

2.3 AREA 31—FORMER RUNWAY FIRE SCHOOL

Area 31 is located approximately 400 yards northeast of the intersection of Runways 13-31 and 7-25 (Figure 4); Area 31 was used for firefighting training from 1967 to 1982. Waste fuels such as aviation gasoline (avgas) and jet petroleum #5 (JP-5), waste oil, solvents, thinners, and other flammable material were ignited and extinguished in a shallow concrete burn pad. The entire drill area consists of 1 to 2 acres, sloping gently southwest. The burn pad, roughly 50 by 50 feet, consists of a retaining lip around its perimeter and a floor that slopes toward a drain in the center. A mixture of flammable liquids used for firefighting training was stored in an UST in the southeast corner of the



CLEAN COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY	**Figure 4** **Area 31, Operable Unit 5** **Former Runway Fire School**	CTO 0162 Operable Unit 5 NAS Whidbey Island, WA ROD

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drill area (175 feet from the burn pad). Oily water from the burn pad was drained through an oil/water separator in the southwest corner of the drill area (200 feet from the burn pad).

Previous firefighting training consisted of igniting flammable material in the pit and extinguishing the fire. In the process of extinguishing the fire, flammable materials may have been forced from the pad onto the surrounding ground.

Unburned liquids were drained from the center of the pad through underground piping to the oil/water separator. After water was separated from floating product, it was discharged to a small ditch that led to a depression in the southwest portion of Area 31 and drained to the runway ditches. Remains of some of the material burned in the pad included ash and metal debris. This material was removed from the pad and piled in various areas on or near the perimeter of the drill area. The ash piles consist of fused metal debris that is broken into chunks, with a small amount of dust-sized particles. Landing gear components are present in the ash piles. Sources of potential chemical releases include activities at the burn pad, the UST, and the oil/water separator, as well as the ash deposited over the area from burning at the pad and the ash piles.

3.0 SITE HISTORY AND ENFORCEMENT ACTIVITIES

3.1 SITE HISTORY

NAS Whidbey Island was commissioned on September 21, 1942. The station was placed on reduced operating status at the end of the war. In December 1949, the Navy began a continuing program to increase the capabilities of the air station. The station's current mission is to maintain and operate Navy aircraft and aviation facilities and to provide associated support activities. Since the 1940s, operations at NAS Whidbey Island have generated a variety of hazardous wastes. Prior to the establishment of regulatory requirements, these wastes were disposed of using practices that were considered acceptable at that time.

In response to the requirements of CERCLA, the U.S. Department of Defense (DoD) established the Installation Restoration (IR) Program. The Navy, in turn, established a Navy IR program to meet the requirements of CERCLA and the DoD IR Program. From 1980 until early 1987, this program was called the Navy Assessment and Control of

Installation Pollutants (NACIP) program. Under the NACIP program, a set of procedures and terminologies were developed that were different from those used by the EPA in administrating CERCLA. As a result of the implementation of SARA, the Navy has dropped NACIP and adopted the EPA CERCLA/SARA procedures and terminology. Responsibility for the implementation and administration of the IR program has been assigned to the Naval Facilities Engineering Command (NAVFACENGCOM). The Southwest Division of NAVFACENGCOM has responsibility for the western states. Engineering Field Activity, Northwest (EFA NW) has responsibility for investigations at NAS Whidbey Island and other naval installations in the Pacific Northwest and Alaska.

3.2 PREVIOUS INVESTIGATIONS AT NAS WHIDBEY ISLAND

The Navy conducted the initial assessment study at NAS Whidbey Island under the NACIP program in 1984. A more focused follow-up investigation and report, the NAS Whidbey Island current situation report, was completed in January 1988. After the current situation report was completed, further investigations were proposed for areas where contamination was verified and where unverified conditions indicated further investigations were appropriate.

While the current situation report was being prepared, EPA Region 10 performed preliminary assessments at NAS Whidbey Island, Ault Field, to evaluate risks to public health and the environment using the Hazard Ranking System.

In late 1985, the EPA proposed that Ault Field be nominated for the National Priorities List (NPL). In February 1990, the site was officially listed as a Superfund site on the NPL. The EPA's inclusion of Ault Field on the NPL was based on the number of waste disposal and spill sites discovered, the types and quantities of hazardous constituents (such as, petroleum products, solvents, paints, thinners, jet fuel, pesticides, and other wastes), and the potential for domestic wells and local shellfish beds to be affected by wastes originating from the site.

As a result of the NPL listing, the Navy, the EPA, and Ecology entered into a federal facility agreement (FFA) in October 1990. The FFA established a procedural framework and schedule for developing, implementing, and monitoring appropriate response actions at NAS Whidbey Island.

Following CERCLA and SARA guidelines, various sites and areas at NAS Whidbey Island were later grouped into "operable units." The term "operable unit" is used to designate specific areas undergoing a remedial investigation/feasibility study (RI/FS). Two areas at Ault Field (Area 1 and Area 52) were collectively identified as OU 5. An RI/FS for OU 5 was conducted in 1994 to 1995, with the final RI/FS report issued in June 1995. The purpose of the RI/FS was to characterize the site, determine the nature and extent of contamination, assess human and ecological risks, and evaluate remedial alternatives.

Two other areas at Ault Field (Area 16 and Area 31) were originally identified as OU 3. An RI/FS for OU 3 was conducted in 1992, with the final RI report issued in January 1994 and the final feasibility study report issued in April 1994. A proposed plan presenting the Navy's preference for remedial action was published for public comment in July 1994. Public comments on the OU 3 proposed plan included questions regarding whether the cost of the preferred alternative at Area 31 was appropriate when compared with the current and potential future risks. Because of these comments, the Navy decided to conduct further study and investigate additional remedial action alternatives for Area 31. To avoid delaying cleanup at Area 16, Area 31 was transferred from OU 3 to OU 5.

A final revised feasibility study report for Area 31 was issued in September 1995. This revised report incorporated additional data collected during two field investigations at Area 31 and evaluated two additional remedial alternatives. A proposed plan for remedial action at OU 5 (now comprising Area 1, Area 31, and Area 52) was published for public comment in October 1995.

4.0 COMMUNITY RELATIONS

The specific requirements for public participation pursuant to CERCLA Section 117(a), as amended by SARA, include releasing the proposed plan to the public. The proposed plan for OU 5 (including Areas 1, 31, and 52) was issued in October 1995, and an open house and public meeting were held on October 24, 1995. The public comment period expired on November 9, 1995. No comments were received on the proposed plan.

- Since February 1994, monthly meetings of the Restoration Advisory Board (RAB) (the function of a RAB is discussed below), which replaced the TRC and provided additional public involvement in OU 5

- A public availability session, held in February 1994, during which information was presented to citizens about the ongoing environmental investigations

- An open house held May 1995 updating the public on the ongoing activities on the projects at NAS Whidbey Island

- Newspaper, radio, television, and poster advertisements for the proposed plan and public meeting

- A public meeting on October 24, 1995, to present the findings of OU 5 investigations and to receive comments on the proposed plan

In the National Defense Authorization Act for Fiscal Year 1995 (Senate Bill 2182), Section 326(a), Assistance for Public Participation in Defense Environmental Restoration Activities, the DoD was directed to establish RABs in lieu of TRCs. In January 1994, NAS Whidbey Island became one of the first Navy facilities to establish a RAB.

The purposes of the RAB are the following:

- To act as a forum for the discussion and exchange of information between the Navy, regulatory agencies, and the community on environmental restoration topics

- To provide an opportunity for stakeholders to review progress and participate in the decisionmaking process by reviewing and commenting on actions and proposed actions involving releases or threatened releases at the installation

- To serve as an outgrowth of the TRC concept by providing a more comprehensive forum for discussing environmental cleanup issues and providing a mechanism for RAB members to give advice as individuals

Documents pertaining to this investigation are available in the following information centers:

Oak Harbor Library
7030 70th N.E.
Oak Harbor, Washington 98277
Phone: (360) 675-5115

Sno-Isle Regional Library System
Coupeville Library
788 N.W. Alexander
Coupeville, Washington 98239
Phone: (360) 678-4911

NAS Whidbey Island Library (for those with base access)
1115 W. Lexington Street
Oak Harbor, Washington 98278-2700
Phone: (360) 257-2702

The Administrative Record is on file at the following location:

Engineering Field Activity, Northwest
Naval Facilities Engineering Command
19917 Seventh Avenue N.E.
Poulsbo, Washington 98370
Phone: (360) 396-0061

Community relations activities have established communication between the citizens living near the site, other interested organizations, the Navy, the EPA, and Ecology. The actions taken to satisfy the statutory requirements also provided a forum for citizen involvement and input to the proposed plan and the ROD. These actions include the following:

- Creation of a community relations plan
- Quarterly meetings of the Technical Review Committee (TRC), which included representatives from the public and from other governmental agencies

The RAB members include representatives from the Navy and regulatory agencies as well as from civic, private, city government, and environmental activist groups. The NAS Whidbey Island RAB, as currently staffed, has substantial representation from interested environmental organizations.

The RAB has been involved in the review and comment process of all project documents. In particular, this group participated in development of the OU 5 decision documents. Members were briefed on and reviewed a draft of the proposed plan prior to the public meeting and reviewed a draft copy of this ROD.

5.0 SCOPE AND ROLE OF OPERABLE UNITS

Potential source areas at NAS Whidbey Island, Ault Field, have been grouped into separate OUs, for which different schedules have been established. Final cleanup actions for OUs 1, 2, and 3 have been selected and RODs have been finalized. For OU 4 (at the Seaplane Base), the ROD was signed in 1993, cleanup actions were completed in 1994, and the site was delisted from the NPL in September 1995. The cleanup actions described in this ROD for OU 5 will mark the end of the Navy's CERCLA investigation at NAS Whidbey Island. These cleanup actions address all known current and potential risks to human health and the environment associated with OU 5.

The Navy is investigating whether past Navy activities at Area 31 have affected adjacent privately owned property. In an effort to avoid delaying the timely cleanup of Area 31, the Navy is addressing the adjacent property separately. The Navy is coordinating these activities directly with the owner of the private property.

6.0 SUMMARY OF SITE CHARACTERISTICS

This section summarizes the physical characteristics and the nature and extent of chemicals detected at OU 5.

6.1 PHYSICAL CHARACTERISTICS

The surface features, surface water hydrology, geology, and hydrogeology of the three areas in OU 5 are described in the following subsections.

6.1.1 Area 1

Area 1 consists of approximately 6 acres bounded on the north by Area 52, on the south by a marshy embayment, on the west by the Strait of Juan de Fuca, and on the east by Saratoga Street and Ault Field. The area is vegetated with grasses and shrubs.

Surface Features

The topography of Area 1 consists of a series of manmade terraces that descends approximately 30 feet from Saratoga Street to the beach. The Beach Landfill is located in the terraced area. The site is incised by two east-west trending drainage swales, or ditches. The northernmost swale forms the northern boundary of the landfill and separates Area 1 from Area 52. The swale is heavily vegetated and varies in depth from 4 to 10 feet and in width from 3 to 10 feet. The second swale, which is located near the middle of the landfill, consists of a wetland area that receives runoff from the outfall of a 24-inch storm sewer crossing under Saratoga Street. The storm sewer outfall discharges storm drainage from lawns and paved areas east of Area 1. An unlined, naturally vegetated ditch discharges water from the wetland to the Strait of Juan de Fuca. The southern end of the Beach Landfill extends into a low-lying beach embayment. The western edge of the landfill is bounded by a small bluff (5 to 10 feet high) that descends to a relatively narrow beach consisting of fine to coarse sand and cobbles.

Vegetation covers the area except where wave action has eroded the toe of the bluff. Construction debris, consisting primarily of concrete blocks and slabs and wooden timbers, is visible along the beach in the toe of the landfill.

Surface Water Hydrology

The investigation of Area 1 was performed during dry weather conditions, when the drainage swales were dry. At the time of the investigation, the wetland areas contained small amounts of water; however, no surface water was discharging from these areas into the Strait of Juan de Fuca. The sources of the water in the wetland in the middle of the landfill were the storm sewer outfall that drains lawn irrigation from the field east of

Saratoga Street, and, possibly, groundwater seeps. The water in the wetland to the south of the landfill is likely the result of groundwater seepage.

Geology

The stratigraphy beneath Area 1 consists of 11 to 22 feet of fill material that has been placed over beach sands. The fill material consists of local borrow material from construction of the base (brown silty clay and sandy silts with some sands and gravels), concrete chunks, and debris. Localized layers of burnt debris are interbedded with the borrow material. This debris consists of burnt paper, wood, concrete, roofing shingles, bottles, metal scraps, and burnt practice-bomb casings. Debris layers vary in thickness from 0.1 to 4 feet. The fill material is underlain by recent beach deposits consisting of fine sand with a trace of gravel. The beach deposits are underlain by glacial deposits consisting of dense sand and gravel deposits.

Hydrogeology

Area 1 and Area 52 are located adjacent to the Strait of Juan de Fuca, a tidally influenced saltwater body. It is assumed that similar groundwater conditions exist at Area 1 and Area 52 because the two areas had similar topography prior to the fill placement, and they appear to have been filled with similar materials. A generalized hydrogeologic profile, relevant to both Area 1 and Area 52, is presented in Figure 5.

Groundwater occurs under unconfined conditions within the beach deposits and glacial sands and gravels beneath the fill. During seasonal wet periods, groundwater may rise into the bottom of the fill materials.

Groundwater beneath the site is recharged by underflow from the area to the east and by infiltration of precipitation falling on the site. Groundwater generally moves northwesterly to the strait. Water level data from Area 52 wells indicate that upgradient groundwater enters Area 1 at a relatively steep gradient and flattens out across the site. Water table fluctuations may cause variations in the direction of local groundwater flow where seasonal water table and daily tidal fluctuations affect the groundwater gradient.

Monitoring of groundwater levels in wells during a previous study of the Jet Engine Test Cell showed that the shallow groundwater system along the beachfront is hydraulically connected to the strait. Tidal data collected during the same study suggest that water levels and the resulting groundwater gradients beneath the area vary in response to tidal fluctuations in the Strait of Juan de Fuca. However, the tidal effects are limited in amplitude; measured water level fluctuations in wells along the beachfront were less than 0.5 foot.

As seen in Figure 5, the water table profile indicates the presence of a freshwater wedge beneath the site. The shape and volume of the wedge likely vary in response to tidal fluctuations and seasonal recharge. The interface, a zone where freshwater and saltwater mixing occurs, forms as a result of the density contrast between fresh and salt water. Because it is less dense than salt water, the fresh water forms a wedge above the salt water. Mixing occurs as a result of head changes in the ocean because of tides, and through seasonal head changes in the aquifer. Discharge of groundwater to the Strait occurs in the intertidal zone.

6.1.2 Area 52

Area 52 is bounded on the west by the Strait of Juan de Fuca, on the east by Saratoga Street, and on the south by Area 1.

Surface Features

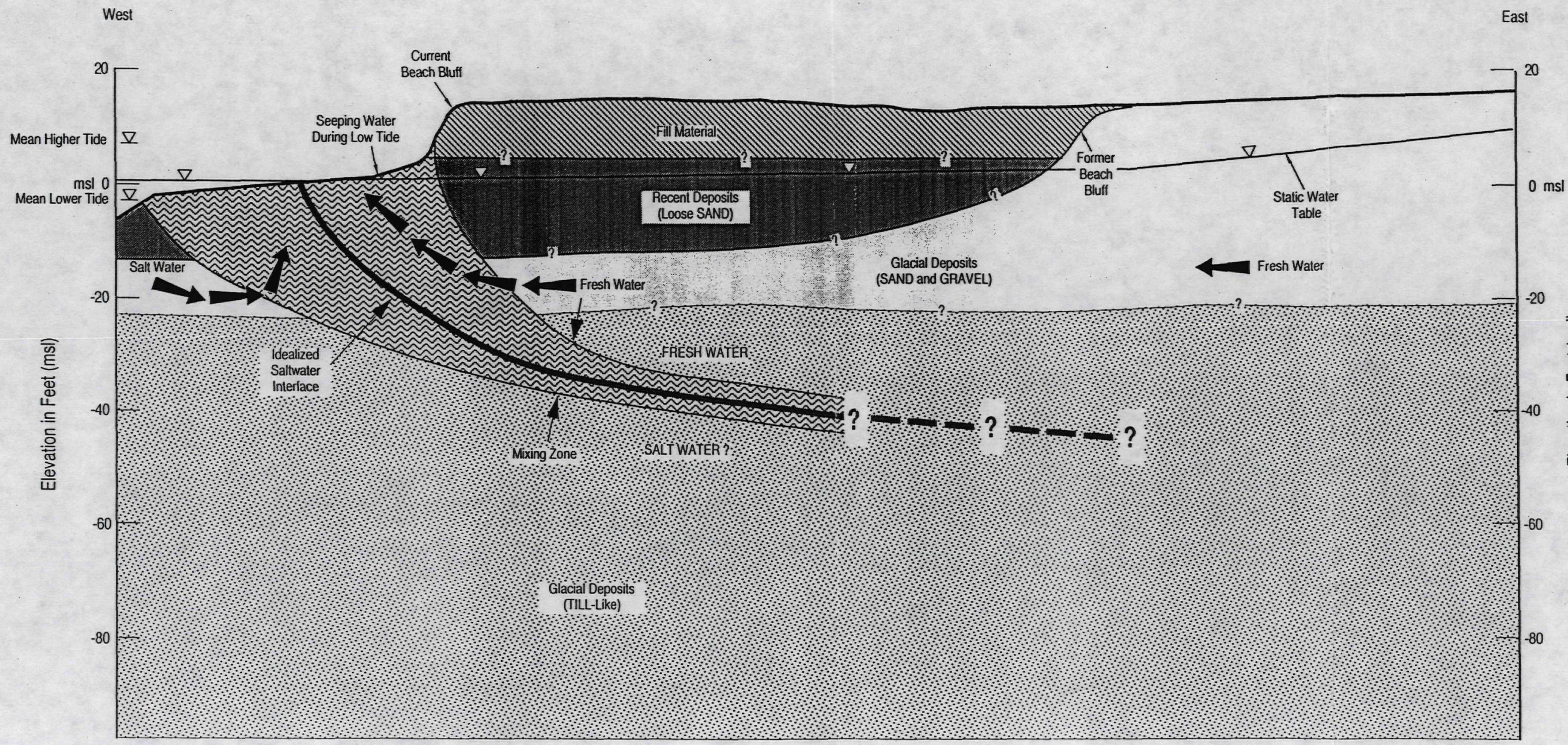
Area 52 is located on a level terrace at the top of a 2- to 10-foot bluff that drops off to a cobble beach and the Strait of Juan de Fuca to the west. Area 1 to the south is separated from Area 52 by a deep swale. Most of Ault Field is located to the east. The Jet Engine Test Cell area is paved, with the test cell building and associated support facilities in the center of the site. The western unpaved portion of the area is maintained as a volleyball court. The vegetation at Area 52 consists of grasses and shrubs.

Geology

The stratigraphy beneath Area 52 is analogous to that of Area 1 (see Section 6.1.1) and consists of 5 to 25 feet of fill material overlying 10 to 20 feet of recent beach deposits. The beach deposits overlie glacial deposits consisting of dense sand and gravel.

Hydrogeology

The hydrogeology of Area 52 is analogous to that of Area 1 (see Section 6.1.1). Groundwater beneath Area 52 occurs under unconfined conditions within the beach



0 40 80 160

Horizontal Scale in Feet

0 20 40

Vertical Scale in Feet

Vertical Exaggeration = 4X

NOTES

1. Profile Adapted from Hart Crowser (1991)
2. Profile is a schematic representation of sediment conditions. Variations in the profile along the bluff are likely to exist.
3. Water table profile based on January 11, 1991, groundwater measurements by Hart Crowser (1991) and maximum water table gradient of 0.005 ft/ft.

LEGEND

- Direction of Flow
- Idealized Fresh Water/Salt Water Interface
- Mixing Zone
- Glacial (TILL-like) Deposits
- Glacial (SAND and GRAVEL) Deposits
- Recent (Loose SAND) Deposits
- Fill Material

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Figure 5
Generalized Hydrogeologic Conditions–Areas 1 and 52

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deposits and glacial sands and gravels beneath the fill. During seasonal high groundwater conditions, the water table may intercept the base of the fill.

Groundwater generally flows west-northwest beneath the site and discharges to the Strait of Juan de Fuca. Local reversal of the gradient has been observed during previous tidal monitoring studies.

As seen in Figure 5, the water table profile indicates the presence of a freshwater wedge beneath the site. The shape and volume of the wedge likely vary in response to tidal fluctuations and seasonal recharge. The interface, a zone where freshwater and saltwater mixing occurs, forms as a result of the density contrast between fresh and salt water. Because it is less dense than salt water, the fresh water forms a wedge above the salt water. Mixing occurs as a result of head changes in the ocean because of tides, and through seasonal head changes in the aquifer. Discharge of groundwater to the strait occurs in the intertidal zone.

6.1.3 Area 31

Area 31 occupies approximately 20 acres on the northern perimeter of the base.

Surface Features

Area 31 is located on nearly flat ground, sloping gently to the southwest. The principal structure is the flat, square concrete burn pad, 50 feet on a side, near the center of the area. The burn pad has a retaining lip and a drain in the middle. The drain connects to a buried pipe that leads southwest from the pad to a buried oil/water separator and discharges through a culvert under the hardstand road. The ditch beyond the culvert drains into a topographically low area. A second ditch runs along the southern edge of the training area and merges into the main ditch on the far side of the hardstand road. There are several piles of ash from firefighting training activities that contain a variety of materials, from dust- and grit-sized particles to gravel and recognizable aircraft parts.

Surface Water Hydrology

Surface water from a small portion of Area 31, in the vicinity of the former UST, flows to the east into a low-lying marsh or wetland on private property (Figure 6). However, surface water from most of Area 31 drains south and west onto Navy property. All locations at Area 31 where surface soil contamination was found are within the zone that

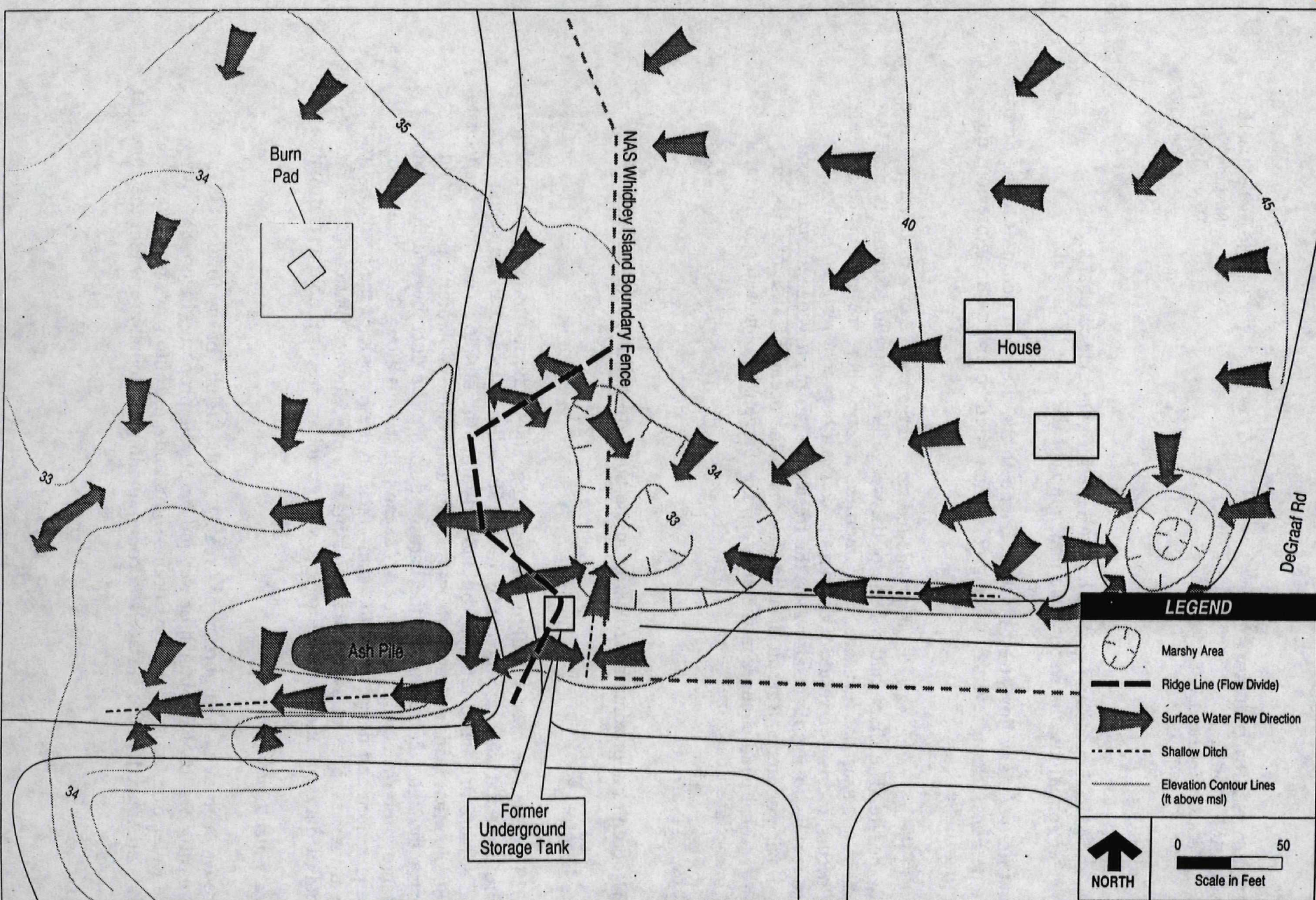

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Figure 6
Surface Water Flow Directions–Area 31 and Adjacent Property

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drains south and west onto Navy property. Therefore, any erosional transport of contaminated surface soil particles by surface water would not result in deposition of contaminants off site.

Geology

The stratigraphy beneath Area 31 consists of Vashon glacial deposits overlying the Whidbey Formation. The locations of two geologic cross sections are shown in Figure 7; the cross sections are presented in Figures 8 and 9.

Vashon recessional outwash deposits at Area 31 generally consist of loose to medium-dense, gravelly, silty sand with thin interbeds of sandy silt (units A and B in cross sections). The total measured thickness of the recessional outwash unit ranges from about 5 to 13 feet. The silt lens (unit B) is up to 3 feet thick.

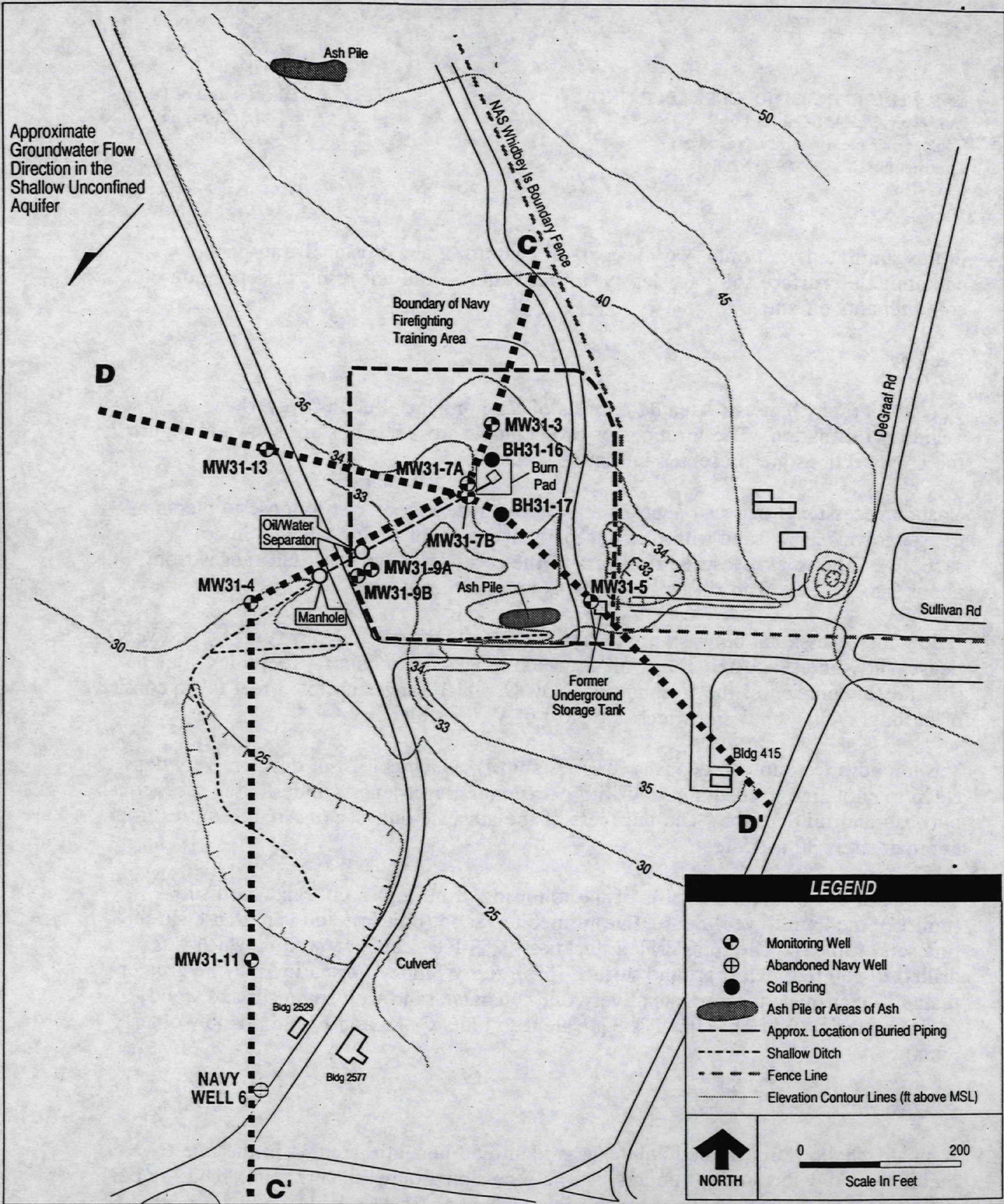
Below the recessional outwash are localized units of stiff silt and clay (unit C) and very dense, silty, fine sand (unit D). Unit C, which ranges up to about 4 feet thick, may be a silt and clay portion of the Vashon till. Unit D, which ranges up to 13 feet thick, consists of hard, gravelly, sandy silt, which is typical of Vashon till.

Vashon advance outwash deposits (units E and F), which consist of dense to very dense, clean to silty, fine to medium sand with occasional gravel lenses, underlie the recessional outwash and till deposits. The thickness of the advance outwash at Area 31 varies from approximately 30 to 45 feet.

The Whidbey Formation consists of the following, from top to bottom: hard silt (unit G); medium to very dense, fine to medium sand (unit H); and very dense silt and fine sand (unit I). The total drilled thickness is 53 feet. In Navy well 6, which was drilled to 156 feet below ground surface (bgs), the Whidbey Formation may be greater than 120 feet thick and consists of very fine to coarse sand with some silt and wood (peat) material (unit J). Unit J is equivalent to units G, H, and I (and possibly older units).

Hydrogeology

A single, shallow, unconfined aquifer was identified beneath Area 31 in the fine to medium sand with some silt underlying the recessional outwash silty sand. This aquifer is the same as the sea level aquifer encountered at Areas 1 and 52.



CLEAN COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY	**Figure 7** **Location of Cross Sections – Area 31**	CTO 0162 Operable Unit 5 NAS Whidbey Island, WA ROD

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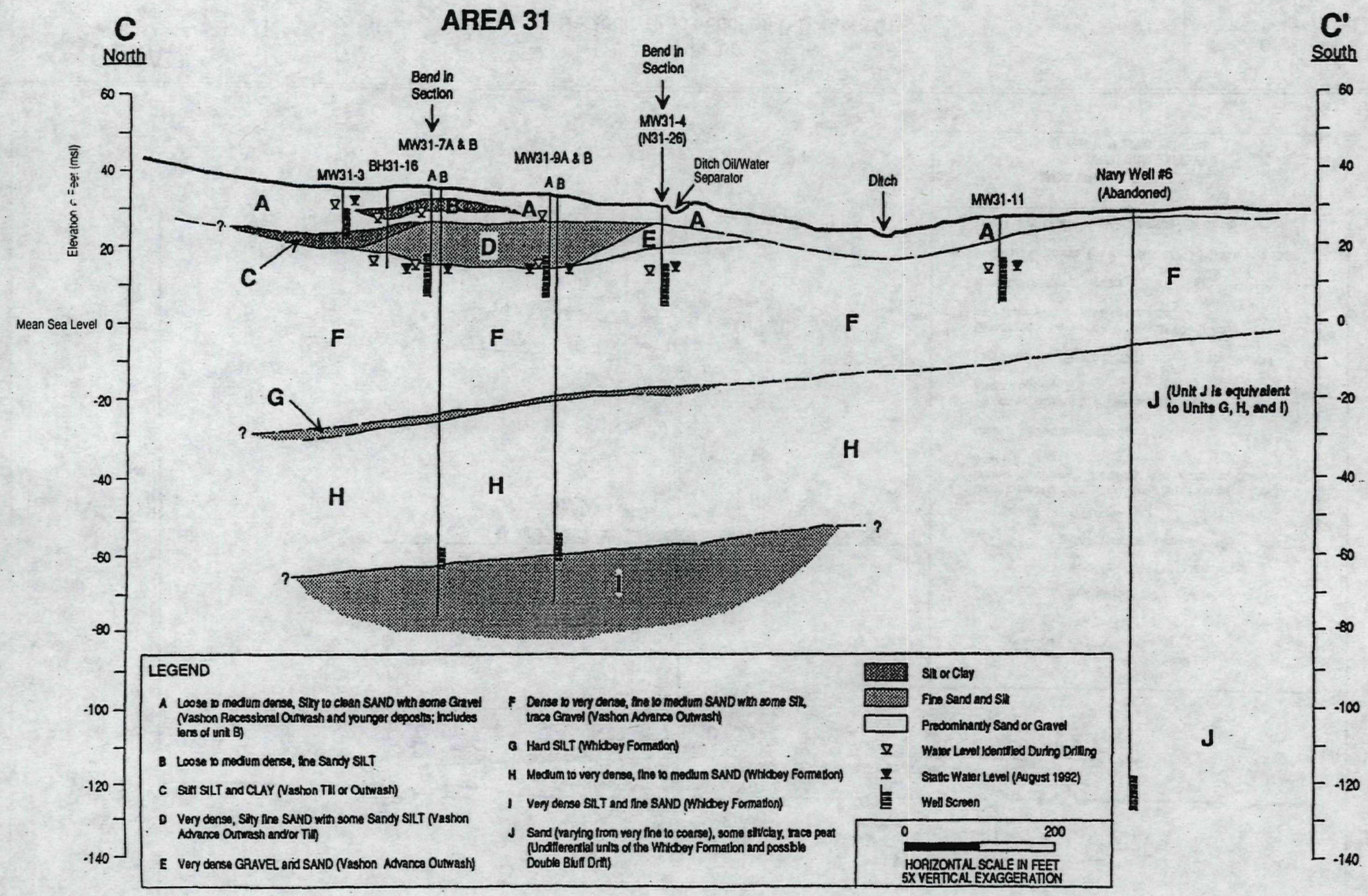

CLEAN COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY	**Figure 8** **Geologic Cross Section C-C'–Area 31**	CTO 0162 Operable Unit 5 NAS Whidbey Island, WA ROD

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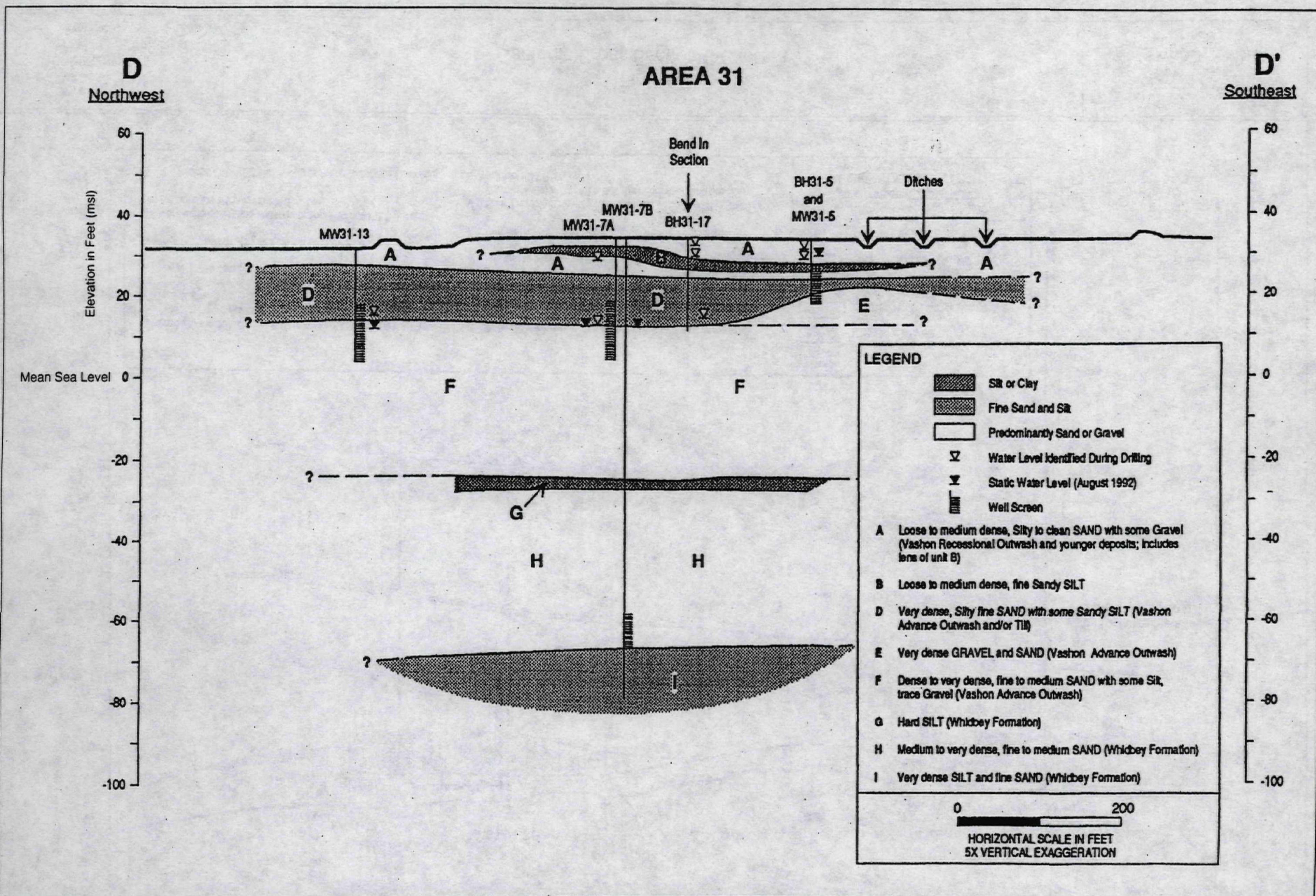

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Figure 9
Geologic Cross Section D-D'–Area 31

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The top of the shallow, unconfined aquifer is between 5 and 20 feet bgs. The base of the aquifer was not reached; however, the sand may be as thick as 150 feet. Localized silt lenses overlying the fine to medium sand have created perched water zones, where the potentiometric heads are substantially higher than those in the surrounding aquifer.

In Area 31, the water table surface ranged from 12.6 to 13.9 feet above mean sea level (msl), and perched water was between 30 and 35 feet above msl. The August water levels for some of the Area 31 wells are shown on the cross sections (Figures 8 and 9).

Although the flow direction and gradient for the perched water zones are unknown, the approximate extent of these perched zones may be inferred from the limits of the fine-grained units. At Area 31, water is perched above units B, C, and D (Vashon glacial units).

It is likely that groundwater in the shallow, unconfined aquifer flowing south from Area 31 eventually discharges through eastern Clover Valley to Dugualla Bay. Groundwater would, therefore, generally follow the topography and surface water flow. Following this hydraulic route, the eastern Navy base boundary is about 1.3 miles downgradient of Area 31. As a result, impacts to groundwater quality at Area 31 could potentially affect off-site water users at the eastern end of Clover Valley, where both surface water and groundwater are used for agricultural purposes, and groundwater is used for domestic drinking water. The nearest private well used for drinking water, downgradient of Area 31, is approximately 1.3 miles away.

6.1.4 Groundwater Potability

The groundwater in the shallow aquifer at Areas 1 and 52 is not considered a potential drinking water source based on the following assumptions:

- Potential future land uses indicate no reason to develop a domestic drinking water well at Area 1 or Area 52. However, if such a well were installed and operated, it is possible that saltwater intrusion would occur, and the water would not be potable because of high salinity.

- The airfield will always serve as an airfield, even if the Navy discontinues use of the base. Areas 1 and 52 are located immediately under the airfield flight line, which precludes their use for future residential development.

- The existing domestic drinking water supply from the Anacortes pipeline is available and will continue to be available for any future demand at Areas 1 and 52.

At Area 31, it is possible that groundwater from the shallow aquifer could be used as a future source of drinking water, although such use is unlikely. Groundwater quality at Area 31 was therefore evaluated based on drinking water criteria.

6.2 NATURE AND EXTENT OF CONTAMINATION

Environmental media sampled during the OU 5 investigation include surface and subsurface soil, groundwater, freshwater sediment, and surface water.

All of the chemicals detected at OU 5 were screened in three steps to focus on chemicals with potential for human health or ecological risk.

In the first step, inorganics were screened against background concentrations. Any inorganic that was at or below background was deleted from consideration. Inorganics that are essential nutrients (aluminum, calcium, magnesium, potassium, iron, and sodium in soils, sediments, and groundwater, and calcium, magnesium, potassium, and sodium in surface water) were also eliminated.

The second screening step identified chemicals of potential concern (COPCs) by screening the chemical concentrations against EPA Region 10 risk-based screening concentrations (RBSCs). These RBSCs use a standard residential exposure assumption, which is the most conservative exposure assumption. For chemicals in soil and sediment, the RBSC designated by EPA is equivalent to a 10^{-7} cancer risk and a hazard quotient (HQ) of 0.1 for noncancer effects. For chemicals in water, the RBSC designated by EPA is equivalent to a 10^{-6} cancer risk and an HQ of 0.1 for noncancer effects. The chemicals that exceeded both background concentrations and Region 10 RBSCs were considered COPCs.

The COPCs were then evaluated in a third screening step to determine chemicals of concern (COCs). Actual exposure scenarios that could occur at each site were evaluated in the risk assessment. At Areas 1 and 52, actual exposure scenarios were used to develop site-specific RBSCs, and detected concentrations of chemicals that exceeded these site-specific RBSCs were considered COCs. At Area 31, actual exposure scenarios were used to develop numeric risk estimates, and any chemical presenting a 10^{-6} cancer risk or an HQ of 0.1 for noncancer effects was considered a COC. At all three areas, any chemical posing a potential ecological risk was also considered a COC, and any chemical detected at concentrations above federal or state screening criteria was considered a COC. Table 1 shows which screening criteria were used for each medium at each site.

The specific methods used in the baseline risk assessment are discussed in detail in Section 7. The following subsections describe the nature and extent of the COCs found at each site.

6.2.1 Area 1

Sampling stations at Area 1 are shown in Figure 10. Table 2 summarizes the COCs identified for Area 1, including the calculated background concentrations used for comparison, the frequency of detections above background, and the range of detected concentrations above background.

Soil

Soil samples were collected at Area 1 from four soil borings and two test pits. Surface and subsurface samples were collected from the soil borings. Only subsurface samples were collected from the test pits. Soil samples were analyzed for target analyte list (TAL) inorganics and target compound list (TCL) pesticides/polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and total petroleum hydrocarbons (TPH).

Petroleum hydrocarbons, copper, lead, and zinc were identified as COCs in Area 1 soils. Concentrations of petroleum hydrocarbons exceeded the Model Toxics Control Act (MTCA) Method A soil cleanup level in one subsurface soil sample collected from Station SB-1 at a depth of 5 to 6.5 feet bgs. MTCA Method A soil cleanup levels for TPH are for the protection of groundwater and not for the protection of human health. Copper, lead, and zinc concentrations did not exceed regulatory criteria, but these inorganics were identified as ecological risk contributors because they exceeded the site-specific ecological RBSCs. However, the ecological risk assessment concluded that actual risks from copper, lead, and zinc were highly uncertain.

No COCs in soil exceeded human health site-specific RBSCs.

Table 1
Screening Criteria Used at OU 5

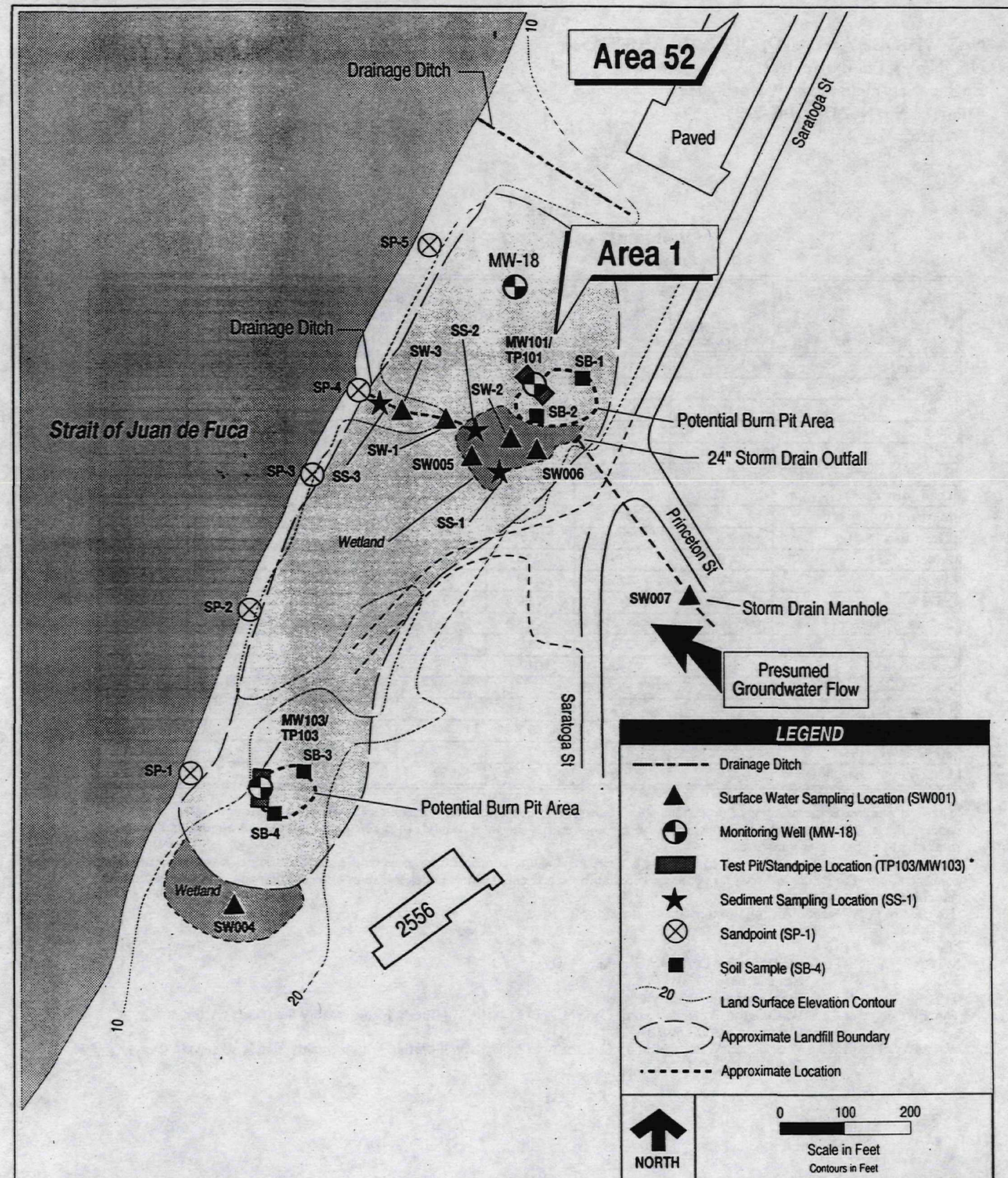
Environmental Medium	Washington Marine Water Quality Standards (Acute & Chronic)	Federal Marine Water Quality Criteria (Acute & Chronic)	Washington Fresh Water Quality Standards (Acute & Chronic)	Federal Fresh Water Quality Criteria (Acute & Chronic)	Drinking Water Standards		Washington Model Toxics Control Act Cleanup Levels		
					Federal	Washington State	Method B Groundwater	Method B Surface Water	Method B Soil
Area 1									
Soil									•
Surface water			•	•					
Freshwater sediment									•
Groundwater	•	•						•	
Area 31									
Soil									•
Ditch sediment									•
Groundwater					•	•	•		
Ash									•
Area 52									
Soil									•
Groundwater	•	•						•	

Notes:

• Screening criterion applies

Sources:

Washington marine water quality standards: Washington Water Pollution Control Act: 90.48 RCW; WAC 173-201A.
Federal marine water quality standards: Clean Water Act (Federal Water Pollution Control Act, 33 USC 1251-1387; CWA 303-304).
Washington fresh water quality standards: Washington Water Pollution Control Act: 90.48 RCW; WAC 173-201A.
Federal fresh water quality criteria: Clean Water Act (Federal Water Pollution Control Act, 33 USC 1251-1387; CWA 303-304).
Federal drinking water standards: Safe Drinking Water Act: 42 USC 300; 40 CFR 141, 143.
Washington drinking water standards: State Board of Health Drinking Water Regulations: WAC 246-290.
Washington Model Toxics Control Act: 70.105D RCW; WAC 173-340.



CLEAN COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY	**Figure 10** **Area 1 Sampling Locations**	CTO 0162 Operable Unit 5 NAS Whidbey Island, WA ROD

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Table 2
Chemicals of Concern at Area 1

Chemical	Background Concentration	Frequency of Detections Above Background[a]	Range of Detections Above Background		Reasons for Selection as a COC		
					Major Risk Contributors[b]		Screening Criteria Exceedance
			Minimum	Maximum	Human	Ecological	
Soil (mg/kg)							
Copper	44.2	4/16	45.6	156		•	
Lead	15.6	6/16	18.1	186		•	
Zinc	100.1	2/16	313	336		•	
TPH	0	6/9	1.2	330			MTCA
Surface Water (µg/L)							
Lead (dissolved)	NC	4/5	2.7	6.5			WA FWQS
Mercury (total)	NC	3/5	0.23	0.43			WA FWQS
Zinc (dissolved)	NC	5/5	9.6	217			WA FWQS
Aroclor 1254	0	4/5	0.16	2.5			WA FWQS
Aroclor 1260	0	1/5	0.99	0.99			WA FWQS
TPH	0	2/4	32,000	350,000			MTCA[c]
Sediment (mg/kg)							
Lead	18.3	3/3	23.3	676			MTCA[c]
Aroclor 1254	0	1/3	0.83	0.83			MTCA[c]
Groundwater (µg/L)							
Cyanide	0	2/3	25.8	152		•	WA MWQS
Zinc (dissolved)	60.5	2/3	65.7	146			WA MWQS
1,1-Dichloroethene	0	1/6	5	5			MTCA
bis(2-Ethylhexyl)phthalate	0	5/9	2	90			MTCA

[a]The first number is the number of detections above background concentration; for chemicals with no background concentration, the number of detections above background equals the total number of detections. The second number is the total number of samples analyzed.
[b]For human health risk, a major risk contributor is a chemical whose concentration exceeds the site-specific risk-based screening concentration. For ecological risk, a major risk contributor is a chemical whose concentration exceeds the ecological risk-based screening concentration.
[c]Exceeds MTCA Method A groundwater cleanup level for TPH.

Notes:

MTCA	Model Toxics Control Act cleanup levels
NC	Not calculated
TPH	Total petroleum hydrocarbons
WA FWQS (A & C)	Washington Water Pollution Control Act (90.48 RCW), Fresh Water Quality Standards (Acute & Chronic) (WAC 173-201A)
WA MWQS (A & C)	Washington Water Pollution Control Act (90.48 RCW), Marine Water Quality Standards (Acute & Chronic) (WAC 173-201A)

Surface Water

Surface water samples were collected from seven freshwater sampling stations at Area 1, including the wetlands, a seep, a downgradient drainage ditch, and an upgradient storm sewer. Surface water samples were analyzed for TAL inorganics (total and dissolved); TCL pesticides/PCBs, VOCs, and SVOCs; and TPH.

Lead, mercury, zinc, PCBs (Aroclors 1254 and 1260), and petroleum hydrocarbons were identified as COCs in Area 1 surface water based on exceedances of state freshwater quality standards. Exceedances occurred within the wetlands and in upgradient stormwater, but not in downgradient drainage from the wetlands. The source of these chemicals appears to be upgradient storm drainage. The PCBs were detected in the sample from the upgradient storm drain, and the other COCs found in the wetlands are common pollutants in urban runoff. The wetlands remove these chemicals from surface water through natural processes such as adsorption, sedimentation, and biodegradation.

No COCs in surface water exceeded human health site-specific RBSCs or were identified as ecological risk contributors.

Sediments

Freshwater sediment samples were collected from three sampling stations within the Area 1 wetlands. Sediment samples were analyzed for TAL inorganics; TCL pesticides/PCBs, VOCs, and SVOCs; and TPH.

Lead and PCBs (Aroclor 1254) were identified as COCs in freshwater sediment samples, based on exceedances of to-be-considered (TBC) guidelines. There are no federal or state standards for freshwater sediments; MTCA soil cleanup levels were used as screening criteria to identify COCs. Concentrations of lead and PCBs exceeded MTCA soil cleanup levels in one sample collected at Station SS-2. The source of these chemicals appears to be upgradient storm drainage.

No COCs in sediment exceeded human health site-specific RBSCs or were identified as ecological risk contributors.

Groundwater

Groundwater samples were collected from two monitoring wells within the Area 1 landfill and from five intertidal sandpoint wells along the eastern shoreline of Area 1. Groundwater discharges to marine surface water in the intertidal zone. Because groundwater at Area 1 is not a current or potential future source of drinking water, groundwater quality was evaluated based on the protection of nearby marine surface water. Groundwater samples were analyzed for TAL inorganics (total and dissolved); TCL pesticides/PCBs, VOCs, and SVOCs; and TPH.

State marine water quality criteria for the following inorganics are based on the dissolved form: cadmium, copper, lead, nickel, silver, and zinc. For all other chemicals, total concentrations are used.

Dissolved zinc, total cyanide, 1,1-dichloroethene, and bis(2-ethylhexyl)phthalate were identified as COCs in Area 1 groundwater based on exceedances of State marine water quality standards. Dissolved zinc exceeded State marine water quality standards in one of three samples, cyanide in two of three samples, 1,1-dichloroethene in one of six samples, and bis(2-ethylhexyl)phthalate in three of nine samples. The accuracy of the cyanide results is suspect because the samples were not properly collected or preserved. Actual concentrations of cyanide in the groundwater may be higher or lower than these cyanide analyses indicated.

Exceedances of these screening criteria indicate some potential for ecological effects. Although the concentrations of these four chemicals in groundwater exceed marine water quality criteria, actual ecological effects in the intertidal zone are uncertain. A biological survey revealed normal communities of plants and animals in the intertidal zone, with no apparent impacts from the landfill. Some attenuation occurs before groundwater discharges to marine surface water as a result of vertical dispersion, tidal flushing, and contaminant loss mechanisms. A very large degree of dilution occurs immediately after groundwater discharges to the intertidal area as a result of mechanical mixing with marine surface water. However, analytical solutions could not be used to quantify these effects because of the complexity of the hydrogeology.

Based on the detected concentrations of cyanide in two inland monitoring wells and hydrogeological information gathered during the RI, the mass loading of cyanide being discharged from Area 1 to the marine environment is estimated at approximately 0.5 pound per year. Because cyanide rapidly volatilizes or biodegrades in surface water and does not bioaccumulate, the relatively low concentrations and mass loadings of cyanide are not expected to affect the marine environment or other ecological receptors.

No COCs in Area 1 groundwater exceeded human health site-specific RBSCs.

6.2.2 Area 52

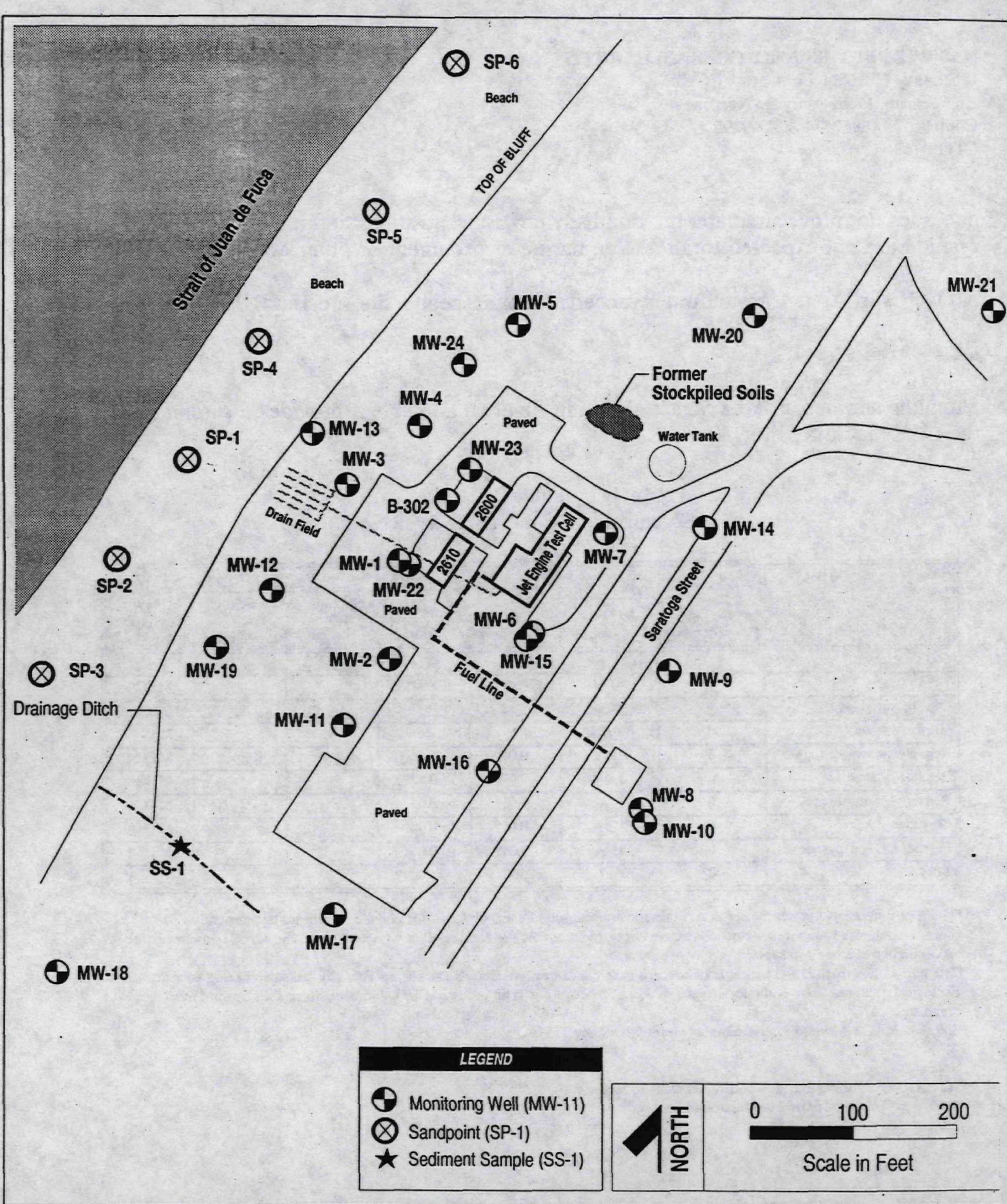
Sampling stations at Area 52 are shown in Figure 11. Table 3 provides a summary of the COCs identified for Area 52.

Table 3
Chemicals of Concern at Area 52

Chemical	Background Concentration	Frequency of Detections Above Background[a]	Range of Detections Above Background		Reason for Selection as a COC		
					Major Risk Contributors[b]		Screening Criteria Exceedance
			Minimum	Maximum	Human	Ecological	
Soil (mg/kg)							
TPH	0	8/19	0.44	1,000,000			MTCA
Groundwater (µg/L)							
Vinyl chloride	0	10/23	2	63			MTCA
Benzo(a)anthracene	0	1/14	0.04	0.04			MTCA
Benzo(a)pyrene	0	1/14	0.07	0.07			MTCA
Benzo(b)fluoranthene	0	1/14	0.05	0.05			MTCA
Chrysene	0	1/14	0.05	0.05			MTCA
Indeno(1,2,3-cd)pyrene	0	1/14	0.04	0.04			MTCA
TPH	0	5/7	500	36,000		•	MTCA[c]

[a]The first number is the number of detections above background concentration; for chemicals with no background concentration, the number of detections above background equals the total number of detections. The second number is the total number of samples analyzed.
[b]For human health risk, a chemical is of concern if its concentration exceeds the site-specific risk-based screening concentrations. Ecological risks were not evaluated for soil at Area 52 because it is an industrial area and subsurface soils are not available to organisms.
[c]Exceeds MTCA Method A groundwater cleanup level for TPH.

Notes:
MTCA Model Toxics Control Act cleanup levels
TPH Total petroleum hydrocarbons



CLEAN COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY	**Figure 11** **Area 52 Sampling Locations**	CTO 0162 Operable Unit 5 NAS Whidbey Island, WA ROD

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Soil

Subsurface soil samples were collected from 15 stations (MW-10 through MW-24) at Area 52. Samples from MW-10 through MW-21 were analyzed for TPH; samples from MW-21 through MW-23 were analyzed for TAL inorganics and TCL pesticides/PCBs, VOCs, and SVOCs. Additionally, six samples were collected from a soil pile on site and analyzed for TPH.

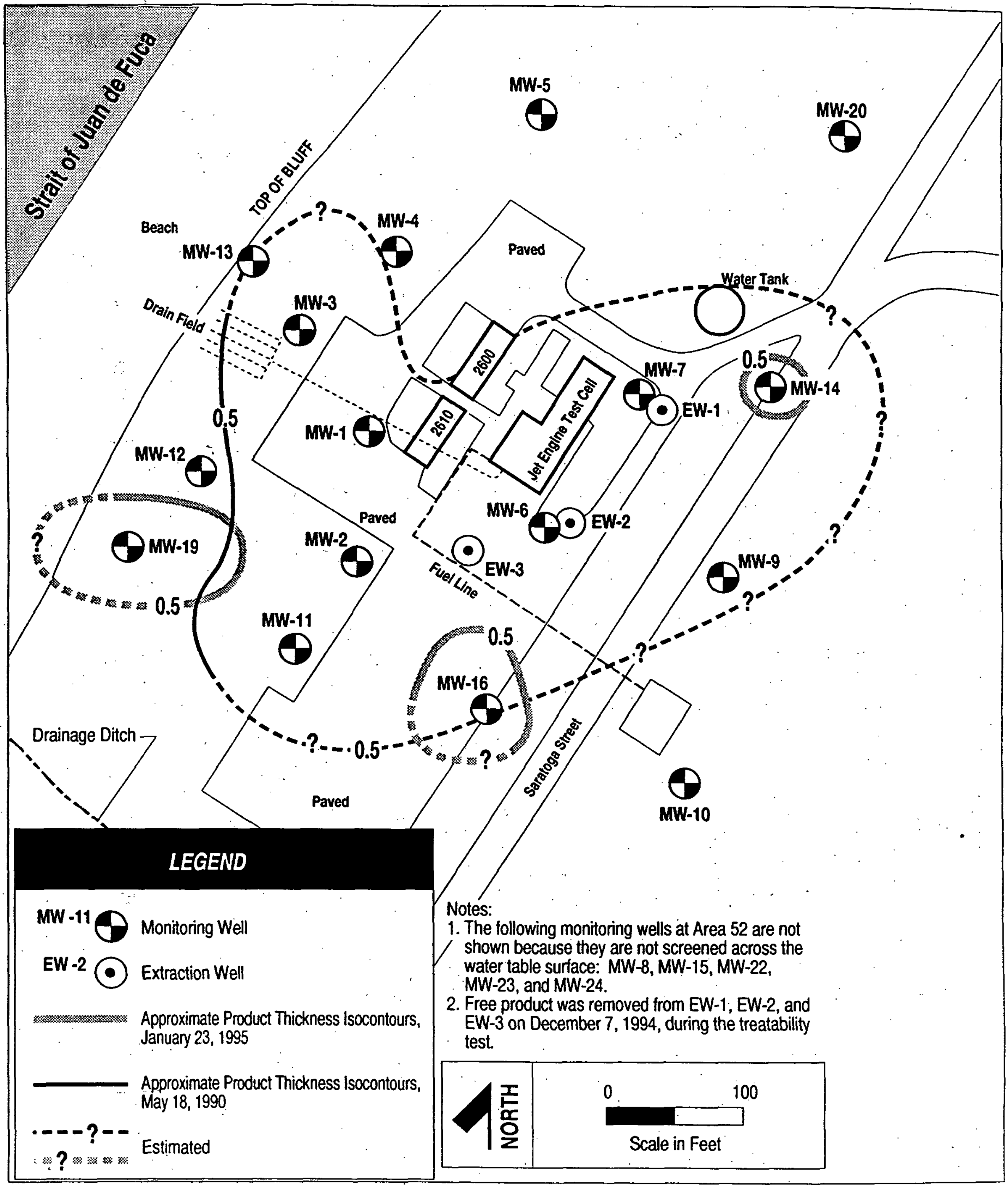
Petroleum hydrocarbons were the only COC identified for Area 52 soils, based on exceedances of MTCA soil cleanup levels. The exceedances occurred in subsurface soils at MW-11, MW-12, MW-14, MW-15, MW-16, and MW-19 at depths of 10 to 16.5 feet bgs. The source of the petroleum is free-phase product that is floating on the groundwater. Subsurface soil samples collected in areas of suspected solvent disposal (MW-22, MW-23, and MW-24) did not contain any chemicals at concentrations above MTCA soil cleanup levels. Petroleum hydrocarbons in the stockpiled soil on site did not exceed MTCA soil cleanup levels.

No COCs in soil exceeded human health site-specific RBSCs. Ecological risks were not evaluated for soil because it is an industrial area, most of which is paved, and subsurface soils are not available to organisms.

Groundwater

Groundwater samples were collected from five intertidal sandpoint wells along the eastern shoreline of Area 52, and analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX) and chlorinated benzenes. In addition to the sandpoint wells, a total of 24 monitoring wells were installed at Area 52. Groundwater samples were generally analyzed for VOCs, SVOCs, polycyclic aromatic hydrocarbons (PAHs), and TPH. As with Area 1, groundwater at Area 52 discharges to marine surface water in the intertidal zone. Groundwater quality was therefore evaluated based on the protection of nearby marine surface water.

Floating petroleum product (jet petroleum fuel #5, or JP-5) was observed on the groundwater at Area 52. The apparent thickness of the floating petroleum product has been measured in monitoring wells from 1990 through 1995. The petroleum product 0.5-foot-thickness contour for January 23, 1995, is shown in Figure 12, along with the contour for petroleum product of the same thickness on May 18, 1990. The thickness of floating petroleum product was greater than 0.5 foot in three small, distinct locations in



Notes:

1. The following monitoring wells at Area 52 are not shown because they are not screened across the water table surface: MW-8, MW-15, MW-22, MW-23, and MW-24.
2. Free product was removed from EW-1, EW-2, and EW-3 on December 7, 1994, during the treatability test.

CLEAN COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY	**Figure 12** **Area 52–Apparent Thickness of Floating Petroleum Product Measured in Monitoring Wells, January 23, 1995, and May 18, 1990**	CTO 0162 Operable Unit 5 NAS Whidbey Island, WA ROD

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January 1995. Measurements made 5 years earlier, on May 18, 1990, indicated that the thickness of floating petroleum product was greater than 0.5 foot in most of the wells at Area 52, covering an area of about 4 acres. These measurements indicate that the thickness of the floating petroleum product is diminishing over time, and the plume appears to be breaking up. In December 1994, a treatability test was conducted to extract groundwater and floating petroleum product at the water table surface. Active pumping was used in three extraction wells. The results of this test demonstrated that the floating petroleum product was not recoverable by active pumping.

Although floating petroleum product was not observed in the intertidal groundwater wells and State marine water quality standards were not exceeded, xylenes were detected at concentrations below 1 $\mu g/L$ in intertidal groundwater wells SP-4, SP-5, and SP-6. This indicates that the more mobile constituents of the floating petroleum product are discharging to the intertidal zone. If the floating petroleum product on groundwater does discharge to surface water, this would violate Washington State water pollution control laws.

Vinyl chloride, PAHs, and petroleum hydrocarbons were identified as COCs in Area 52 groundwater, based on exceedances of marine surface water regulatory criteria. Vinyl chloride occurred in groundwater samples collected from MW-3, MW-4, MW-5, and MW-13, with the highest concentrations and most frequent detections at MW-4. These wells are all screened at the top of the aquifer. The data indicate that the source of vinyl chloride is near MW-4, and that vinyl chloride concentrations decrease away from MW-4. PAHs were detected above regulatory criteria in two samples. The floating petroleum product is the likely source of the PAH compounds in groundwater.

Monitoring wells MW-22, MW-23, and MW-24 were installed in areas of suspected solvent disposal and were screened at the base of the aquifer to allow monitoring for heavier free-phase or dissolved chlorinated solvents (chlorinated VOCs). No chlorinated VOCs were detected in water samples collected from MW-22, MW-23, and MW-24, indicating that pools of free-phase chlorinated solvent are not present at the base of the aquifer.

Bis(2-ethylhexyl)phthalate was detected above regulatory criteria in seven samples and in a laboratory blank. Because bis(2-ethylhexyl)phthalate is a common laboratory contaminant and is not associated with historical activities at this site, it is not considered a COC.

The COCs in groundwater could pose ecological risk if they exceed State marine water quality standards at the point of groundwater discharge (i.e., in the intertidal zone). The existing data indicate that this is not the case. However, floating petroleum product could pose ecological risks if it migrates to surface water.

No COCs in groundwater exceeded human health site-specific RBSCs.

6.2.3 Area 31

Three phases of environmental sampling have occurred at Area 31. Phase I and II sampling stations at Area 31 are shown in Figure 13. During the OU 3 RI, Phase I (June to August 1992) and Phase II (December 1992) involved the collection of surface and subsurface soil, groundwater, and ditch sediment samples. Phase I and Phase II information was used in the risk assessment. Table 4 summarizes the COCs identified for Area 31 during Phase I and Phase II. Three additional investigations (denoted Phase III) were later conducted. First, in September and October 1994, the 4,000-gallon UST was removed from Area 31, and subsurface soil samples were collected near the UST and its associated piping. Second, in January and February 1995, a construction delineation sampling program was conducted involving (1) surface soil sampling near the burn pad and the oil/water separator, (2) subsurface soil sampling near the oil/water separator, (3) removal of PCB-contaminated surface soils, along with confirmation sampling of surface soils, and (4) groundwater sampling near the oil/water separator. Third, in the fall of 1995, additional soil and groundwater samples were collected from three monitoring wells/boreholes in the vicinity of the former UST (which was removed in September and October 1994). Table 5 summarizes the COCs identified at Area 31 during the Phase III investigations. Because the Phase III data were collected after the risk assessment was conducted, the Phase III data are not included in risk calculations.

Surface and Subsurface Soil

A total of 82 surface and subsurface soil samples (including 2 ditch sediment samples) were collected at Area 31 during Phase I of the RI. During Phase III, surface soil samples were collected from an additional five stations in the area of the PCB removal action (near Station 31-22) and from 33 stations around the burn pad and oil/water separator. Also during Phase III, subsurface soil samples were collected from 18 borings near the oil/water separator and 7 stations near the UST and associated piping. Surface and subsurface soil samples were also collected from three monitoring well boreholes

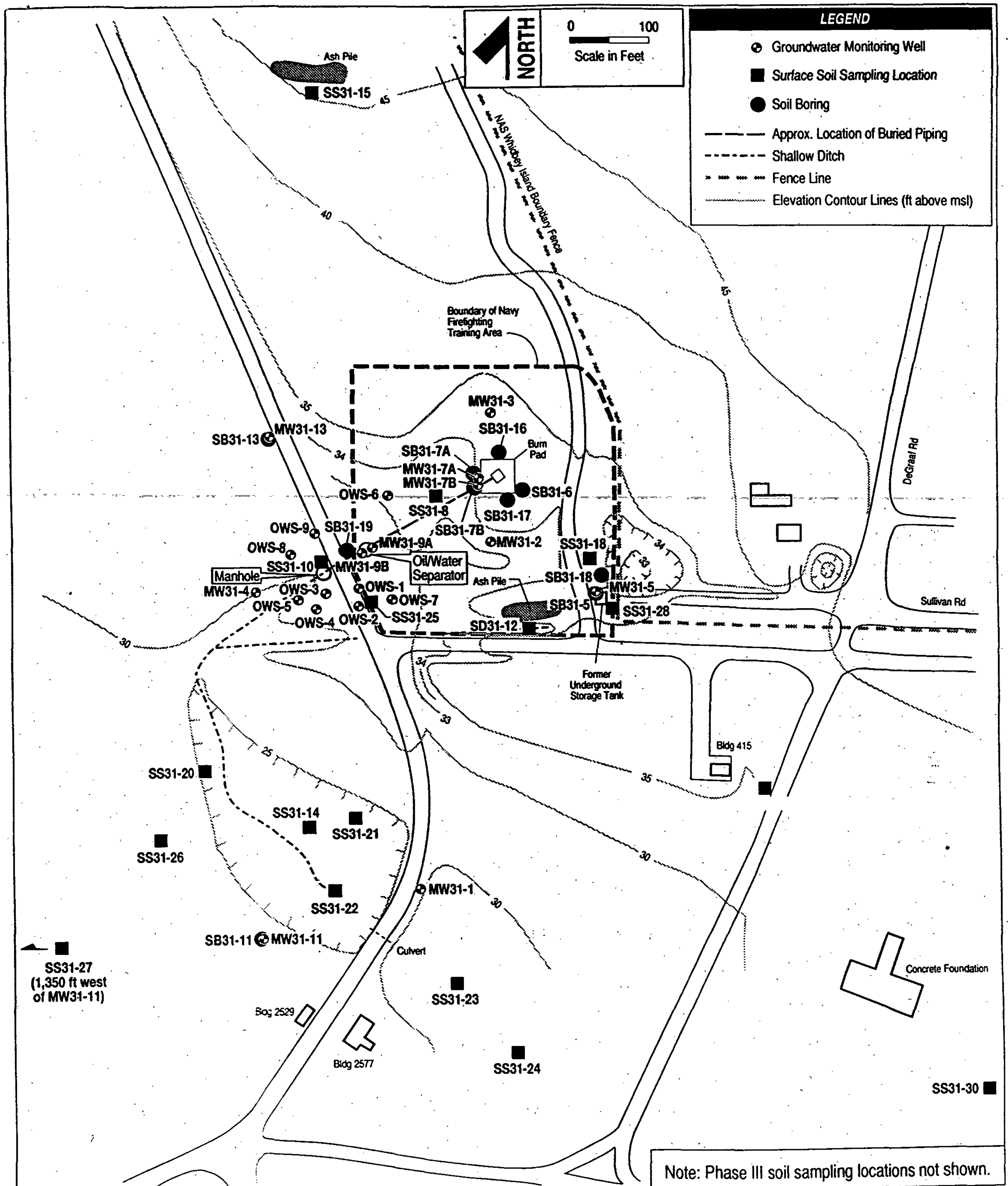

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Figure 13
Area 31 Sampling Locations

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Table 4
Chemicals of Concern at Area 31
(Phase I and Phase II—Included in Risk Assessment)

Chemical	Background Concentration	Frequency of Detections Above Background[a]	Range of Detections Above Background		Reasons for Selection as a COC		
					Major Risk Contributors[b]		Screening Criteria Exceedance
			Minimum	Maximum	Human	Ecological	
Surface and Subsurface Soil (mg/kg)[c]							
Beryllium	0.52	21/81	0.53	0.88			MTCA
Lead	15.6	17/71	16.1	834	•	•	MTCA
Indeno(1,2,3-cd)pyrene	0	3/85	0.14	0.20			MTCA
Aroclor 1260	0	28/82	0.0084	0.75			MTCA
Dioxins	0	8/17	0.052×10^{-6}	9.44×10^{-5}		•	MTCA
TPH	0	37/78	57	16,900			MTCA
Ash (mg/kg)							
Lead	15.6	3/3	245	544	•		MTCA
Groundwater (µg/L)							
Aroclor 1260	0	1/11	0.7[f]/ND	0.7[f]/ND			MTCA
Benzene	0	3/17	1	380[f]/5			MTCA
Dioxins (TEC-pg/L)	0	4/6	0.18	5,303[f]/0.396			MTCA
Lead (total)	9.7	2/17	11	198[f]/11			MTCA
Manganese (total)	560	6/17	674	3,030	•		MTCA
Manganese (dissolved)	125	8/17	156	2,590	•		MTCA
Mercury (dissolved)	2[d]	1/17	3.6	3.6			WA MCL
Naphthalene	0	2/14	2	900[f]/2			MTCA
TPH	0	1/11	231,000[f]/ND	231,000[f]/ND	•[e]		MTCA
Toluene	0	4/17	1	3,200[f]/5			FED MCL

[a]The first number is the number of detections above background concentration; for chemicals with no background concentration, the number of detections above background equals the total number of detections. The second number is the total number of samples analyzed.
[b]For human health risk, if combined cancer risk is greater than 10^{-4}, a major risk contributor is a chemical in a medium that contributes greater than 10^{-5} to the total risk. For noncancer risk with an HI greater than 1.0, a major risk contributor is a chemical in a medium that contributes an HQ greater than 0.1. For ecological risk, a chemical that contributes an HQ greater than 1.0 is a major risk contributor.
[c]Includes ditch sediment.
[d]Background concentrations were not determined; the most stringent ARAR value is shown.
[e]Floating petroleum product is assumed to pose a potential human health risk if drinking water wells were developed at Area 31.
[f]Detections occurred in a single sample that contained a sheen of floating petroleum and are not representative of groundwater quality in the aquifer.

Notes:
This table includes data collected during the Phase I (June to August 1992) and Phase II (December 1992) investigations. The data summarized in this table were used in the risk assessment.

FED MCL	Federal Safe Drinking Water Act (42 USC 300) Maximum Contaminant Levels (40 CFR 141)
MTCA	Model Toxics Control Act cleanup levels
ND	Not detected

Table 4 (Continued)
Chemicals of Concern at Area 31
(Phase I and Phase II—Included in Risk Assessment)

TEC	Toxicity equivalency concentration (individual dioxins/furans concentrations were converted to equivalent concentrations of 2,3,7,8-tetrachlorodibenzo-p-dioxin using EPA's toxicity equivalency factors [U.S. EPA 1989b])
TPH	Total petroleum hydrocarbons
WA MCL	Washington State Maximum Contaminant Levels (WAC 246-290)
pg/L	Picograms per liter

Table 5
Chemicals of Concern at Area 31
(Phase III—Post Risk Assessment)

Chemical	Background Concentration	Frequency of Detections Above Background[a]	Range of Detections Above Background		
			Minimum	Maximum	Screening Criteria Exceedance
Surface and Subsurface Soil (mg/kg)					
Aroclor 1260	0	4/15	0.13	2.3	MTCA
TPH	0	29/84	6.8	68,000	MTCA
Groundwater (µg/L)					
Benzene	0	2/17	23	87	MTCA
Beryllium (total)	0	2/17	0.29	3.4	MTCA
Beryllium (dissolved)	0.0203[b]	1/17	0.20	0.20	MTCA
Dioxins (TEC-pg/L))	0	9/14	0.0018	0.594	MTCA
Lead (total)	9.7	3/17	15.2	31.9	MTCA
Manganese (total)	560	9/17	1,490	3,780	MTCA
Manganese (dissolved)	125	13/17	129	3,900	MTCA
Pentachlorophenol	0	1/17	7	7	MTCA
TPH	0	14/17	150	1,000	MTCA
Styrene	0	1/17	2	2	MTCA
Vinyl chloride	0	3/17	2	4	MTCA

[a]The first number is the number of detections above background concentration; for chemicals with no background concentration, the number of detections above background equals the total number of detections. The second number is the total number of samples analyzed.
[b]Background concentrations were not determined; the most stringent ARAR value is shown.

Notes:
This table includes data collected during the Phase III (1995) investigations. The data summarized in this table were collected after the risk assessment was completed.

FED MCL	Federal Safe Drinking Water Act (42 USC 300) Maximum Contaminant Levels (40 CFR 141)
MTCA	Model Toxics Control Act cleanup levels
pg/L	picograms per liter
TEC	Toxicity equivalency concentration (individual dioxins/furans concentrations were converted to equivalent concentrations of 2,3,7,8-tetrachlorodibenzo-p-dioxin using EPA's toxicity equivalency factors [U.S. EPA 1989b])
TPH	Total petroleum hydrocarbons
WA MCL	Washington State Maximum Contaminant Levels (WAC 246-290)

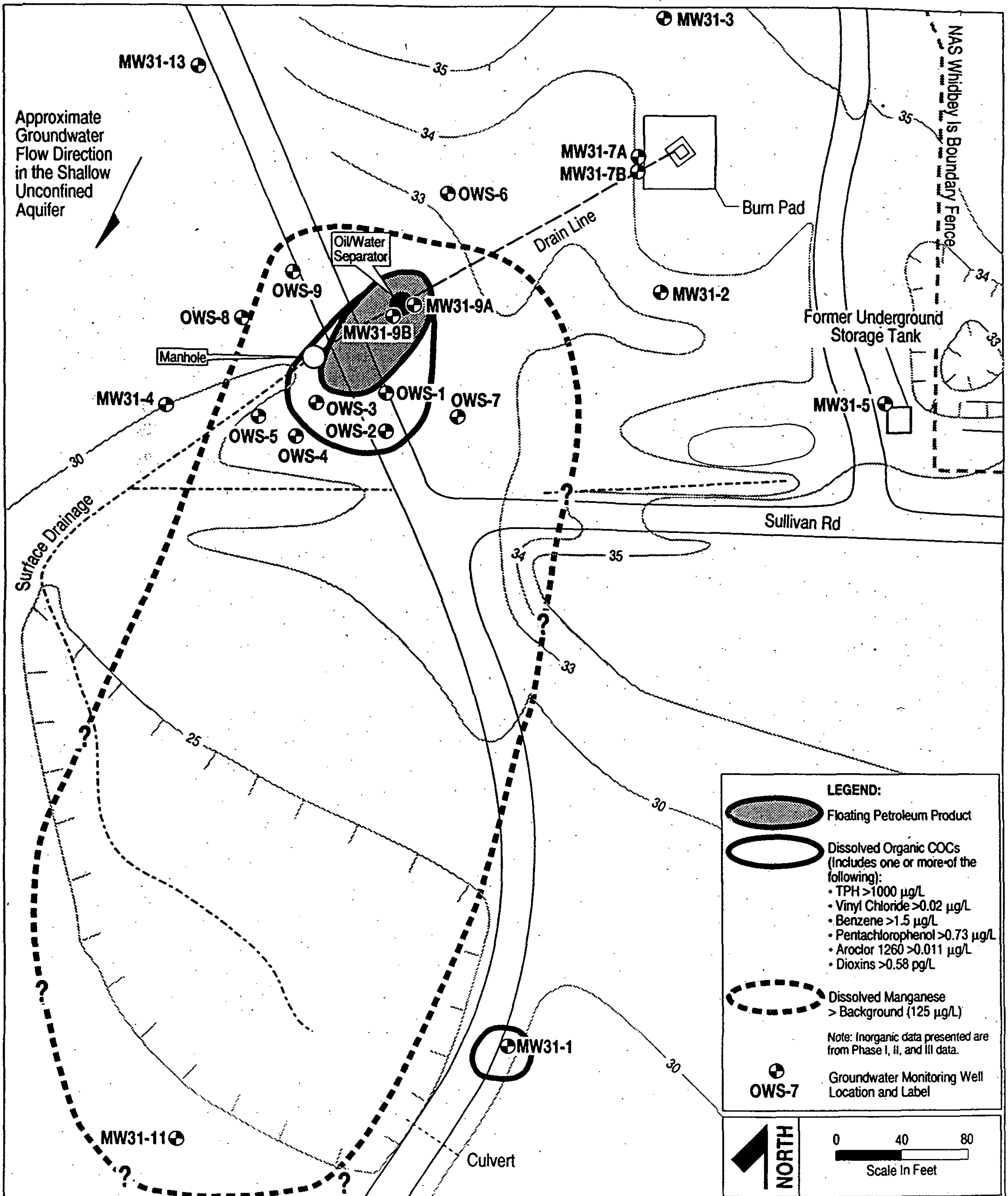
As shown in Tables 4 and 5, a total of 13 COCs were identified in Area 31 groundwater: the inorganics beryllium, lead, manganese, and mercury, and the organics PCBs (Aroclor 1260), benzene, dioxins, naphthalene, pentachlorophenol, petroleum hydrocarbons, styrene, toluene, and vinyl chloride. In Table 4, some of the maximum detected values for COCs in groundwater are attributable to a groundwater sample collected from MW 31-9A during Phase I. This well contained floating petroleum product, and the groundwater sample contained a sheen of petroleum that influenced the analytical results. Therefore, results from this sample are not representative of actual groundwater quality. The affected results are indicted by a footnote in the table, and the next highest detection is presented as a more accurate representation of groundwater quality.

Figure 14 shows the approximate limits of the floating petroleum product, dissolved manganese, and other organic COCs in the shallow unconfined aquifer. With the exception of the inorganics beryllium and manganese, each of the COCs in groundwater exceeded drinking water screening criteria near the oil/water separator and/or the UST and are associated with petroleum floating on the groundwater in these locations. The COCs associated with the petroleum exceeded drinking water screening criteria in wells immediately downgradient of the oil/water separator.

Bis(2-ethylhexyl)phthalate was detected above regulatory criteria in a total of two groundwater samples at Area 31. Because bis(2-ethylhexyl)phthalate is a common laboratory contaminant and is not associated with historical activities at this site, it is not considered a COC.

Beryllium does not appear to be associated with petroleum floating on the groundwater. Total beryllium occurred in 1 of 34 samples and dissolved beryllium occurred in 1 of 34 samples. The detections of total and dissolved beryllium occurred at stations OWS-8 and MW31-4, respectively. No known sources of beryllium exist. Beryllium occurred in Area 31 soils at concentrations no greater than 1.7 times the calculated background concentration.

Manganese exceeded drinking water screening criteria and background concentrations in 15 of 34 total analyses and 21 of 34 dissolved analyses. The approximate limits of the dissolved manganese plume in the shallow, unconfined aquifer are shown in Figure 14. The presence of petroleum in subsurface soils may be creating reducing conditions, which can cause partitioning of manganese from soil to groundwater. The downgradient extent of the dissolved manganese plume has not yet been defined. Future remediation



CLEAN COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY	Figure 14 COCs in Area 31 Groundwater - Shallow Unconfined Aquifer	CTO 0162 Operable Unit 5 NAS Whidbey Island, WA ROD

533162004-100a-051596

near the UST. Soil samples were analyzed for TAL inorganics; TCL pesticides/PCBs, VOCs, and SVOCs; dioxins/furans; and TPH.

Beryllium, lead, indeno(1,2,3-cd)pyrene, PCBs (Aroclor 1260), dioxins, and petroleum hydrocarbons were identified as COCs in Area 31 soils. Beryllium exceeded the MTCA Method A soil cleanup level in 21 of 81 surface and subsurface samples; however, no clear distribution pattern was evident, and the maximum detected concentration was only 1.7 times the background concentration. Lead exceeded the MTCA Method A soil cleanup level in 2 of 71 samples. The lead exceedances occurred in a surface soil sample collected at Station 31-8 and a ditch sediment sample collected at Station 31-12. The PAH indeno(1,2,3-cd)pyrene exceeded the MTCA Method B soil cleanup level in 3 of 70 samples. The PAH exceedances occurred in surface soil samples collected near the burn pad at Stations 31-6, 31-8, and 31-16. The PCB Aroclor 1260 exceeded the MTCA Method B soil cleanup level in 7 of 87 samples. The PCB exceedances occurred in surface soil samples collected at Stations 31-6, 31-14, 31-17, and 31-22. In Phase III, a soil removal action was conducted at Station 31-22, where the highest PCB concentration was found. Approximately 2 cubic yards of soil were removed. However, three of the five confirmation samples from the excavated area still exceeded MTCA Method B soil cleanup level of 0.13 mg/kg. The maximum detected PCB concentration in the confirmation samples was 2.3 mg/kg. Dioxins exceeded the MTCA Method B soil cleanup level in 8 of 17 samples. The dioxin exceedances occurred in surface soil samples collected near the burn pad at Stations 31-6, 31-7A, and 31-8. Petroleum hydrocarbons exceeded the MTCA Method A soil cleanup level in a total of 22 surface and 35 subsurface soil samples. Petroleum hydrocarbons were found in surface soils near the burn pad, near the oil/water separator, and downgradient of the oil/water separator. Petroleum hydrocarbons were found in subsurface soils near the burn pad, the oil/water separator, and the UST.

Lead and dioxins in surface soil were identified as potential ecological risk contributors. As will be discussed in Section 7, potential ecological risks are limited to the masked shrew.

Lead was identified as a human health COC in Area 31 ditch sediment because of one detection above the EPA soil action level. This detection occurred in surface sediment sample SD-12, immediately adjacent to an ash pile.

Ash

Three ash samples (the by-product materials of fire training activities) were collected from Stations 31-12 and 31-15. Ash samples were analyzed for TAL inorganics, TCL pesticides/PCBs, VOCs, and SVOCs, dioxins/furans, and TPH. One ash sample was analyzed for toxicity characteristics leaching procedure (TCLP) parameters.

Only lead was identified as a COC in ash, based on exceedances of the MTCA Method A soil cleanup level, which was used as a screening level for ash. Lead exceeded the MTCA Method A soil cleanup level in two of three ash samples. No chemicals exceeded regulatory levels in the TCLP extract sample.

Lead was identified as a human health COC in Area 31 ash because of one detection above the EPA soil action level. This detection occurred in ash sample PR 31-12. The ash was not evaluated for ecological risk.

Groundwater

A total of 23 groundwater monitoring wells were sampled one or more times during the three phases of field investigations at Area 31. Eighteen of the wells were screened in the shallow (sea level) aquifer. Five of the wells (MW31-3, MW31-5, MW31-31, MW31-32, and MW31-33) were screened in the perched aquifer. Although the perched aquifer is not a potential source of drinking water, it likely drains to the shallow aquifer beneath it. Because groundwater from the shallow aquifer at Area 31 is a potential source of drinking water, the analytical results from all groundwater samples were compared to drinking water screening criteria (maximum contaminant levels [MCLs] and MTCA Method B groundwater cleanup levels). Groundwater samples were analyzed for TAL inorganics (total and dissolved); TCL pesticides/PCBs, VOCs, and SVOCs; dioxins/furans; and TPH.

Floating petroleum product was found on shallow aquifer groundwater near the oil/water separator in monitoring well MW 31-9A. Borings completed in the Phase III field investigation verified the limits of the petroleum near the oil/water separator. Additionally, some free-phase petroleum was found floating on perched aquifer groundwater during removal of the UST in the Phase III field investigation. The approximate limits of the floating petroleum product plume near the oil/water separator are shown in Figure 14.

of the petroleum constituents in soil and groundwater may shift the groundwater to oxidizing conditions, causing the manganese to precipitate out of the groundwater.

Manganese was identified as a human health COC in the risk assessment based on potential future use of groundwater as drinking water. Also, petroleum was identified as a human health COC based on the assumption that floating petroleum product would pose a human health risk if drinking water wells were developed at Area 31.

No ecological COCs were identified for Area 31 groundwater.

7.0 SUMMARY OF SITE RISKS

Human health and ecological risk assessments were conducted as part of the RI of OU 5 to evaluate current and potential future risks associated with exposures to detected chemicals. These risk assessments indicate the risks that could exist if no remedial actions were taken, considering not only current land uses but also potential future uses. The results of the risk assessments were used in evaluating the need for remedial action at Area 1, Area 52, and Area 31. A summary of the procedures and findings of the human health and ecological risk assessments is presented in the following subsections.

7.1 HUMAN HEALTH RISK ASSESSMENT

Focused human health risk assessments were conducted for Area 1 and Area 52, and a baseline human health risk assessment was conducted for Area 31. The first step of both types of human health risk assessments is chemical screening to identify COPCs. This is accomplished by comparing detected concentrations against background concentrations and EPA Region 10 RBSCs for residential use. In the baseline human health risk assessment for Area 31, after identification of COPCs, an exposure assessment and a toxicity assessment were used to calculate quantitative risk estimates for each chemical in each medium. As discussed in Section 6, the original human health risk assessment at Area 31 includes only Phase I and Phase II data. A brief review of the data collected after the Phase I and II investigations was performed and is discussed in Section 7.1.5. In the focused human health risk assessment for Area 1 and Area 52, an exposure assessment was used to develop site-specific RBSCs. The assumptions used in developing the site-specific RBSCs are discussed in Section 7.1.2. Detected concentrations of COPCs were compared against the site-specific RBSCs to determine if the potential existed for risk and what the general magnitude of the risk might be. The COPCs exceeding the site-specific RBSCs at Areas 1 and 52 and the COPCs showing unacceptable risk in the baseline risk assessment for Area 31 are considered COCs. Specific methods for each step (chemical screening, exposure assessment, toxicity assessment, and risk characterization) are discussed in the following subsections.

7.1.1 Chemical Screening

The analytical results for each area at OU 5 were evaluated by a number of initial screening steps to identify COPCs. These COPCs were carried through the remainder of the risk assessment to quantify risks at OU 5 and to determine the chemicals that contribute most significantly to overall site risks. The chemical screening steps used to establish COPCs included the following:

- *Sample grouping.* For each environmental medium, samples were selected that were most representative for a particular exposure pathway. For example, analytical results for chemicals in soil samples from the upper 2 feet of soil were used for current human exposures, whereas samples from the upper 15 feet of soil were used for future exposures because deeper soil might be brought to the surface by future construction activities.

- *Data validation.* The quality of the data was evaluated, in accordance with EPA guidance, to assess whether each chemical result was suitable for use in the risk assessment. Data rejected because of inadequate quality were not carried forward in the quantitative risk assessment.

- *Nondetected chemicals.* If a chemical was not detected in any of the samples for a particular medium, the chemical was eliminated from further consideration in the risk assessment.

- *Essential nutrients.* Certain inorganic chemicals were not included in the risk calculations because they are essential nutrients that are either nontoxic or toxic at only high concentrations. This screening was in accordance with EPA guidance, which approves of eliminating such nutrients from the human health risk assessment.

- *Toxicity.* The maximum detected concentrations in each medium were compared with RBSCs for residential use developed by EPA Region 10. For chemicals in water, the RBSC designated by EPA corresponds to a 10^{-6} risk level for cancer effects and an HQ of 0.1 for noncancer effects. For soil and sediment, the RBSC is equivalent to a 10^{-7} cancer risk and an HQ of 0.1. These RBSCs represent conservative risk levels so that significant risk-causing chemicals will not be screened out.

- ***Background.*** Inorganic chemical concentrations that were not eliminated by comparison to RBSCs were compared with background concentrations to determine whether they were present on site at elevated levels. Background data for inorganics were used to screen on-site chemicals because inorganics are naturally occurring components of environmental media (i.e., soils and groundwater). Background screening was not conducted for organic chemicals because most of these chemicals are not normally found in environmental media.

All chemicals that still remained as COPCs following the chemical screening were further evaluated in the risk assessment.

7.1.2 Exposure Assessment

The purpose of the exposure assessment was to quantify potential human contact with COPCs identified at the site. This was accomplished by identifying the exposure media, the potentially exposed populations (based on current and future land uses), and the routes of exposure; and by quantifying the human intake of chemicals for these media, populations, and exposure routes. The exposures that were evaluated are summarized in Table 6.

Potentially exposed populations (receptors) and exposure routes (pathways) were identified for current and potential future land uses for each of three areas in OU 5. The populations that were considered at each area included one or more of the following: current on-site workers, future industrial workers, future recreational visitors, and future residents. Exposure pathways pertinent to each area, population, and medium are identified in Table 6.

In order to calculate the human intake of chemicals, exposure point concentrations must be estimated. Exposure point concentrations are the concentrations of each chemical to

Table 6
Human Exposure Models Selected to Evaluate Potential Risks From Chemicals at OU 5

Environmental Medium	Area 1[a]						Area 52[a]			Area 31[b]					
	Future Recreational Visitor			Future Industrial Worker			Future Industrial Worker			Current On-Site Worker			Future Resident		
	ING	INH	DC	ING	INH	DC	ING	INH	DC	ING	INH	DC	ING	INH	DC
Soil	x	x		x	x		x	x		x	x	x	x	x	x
Sediment	x	x													
Surface water	x	x													
Groundwater													x	x	x

[a]Screening-level risk assessment, using the EPA default RBSCs
[b]Baseline risk assessment

Notes:
ING Ingestion
INH Inhalation
DC Dermal contact

which an individual may potentially be exposed for each medium at the site. Exposure point concentrations were developed from analytical data obtained during the investigation.

Exposure point concentrations were calculated for both an average exposure and a reasonable maximum exposure (RME). The RME corresponds to the highest plausible degree of exposure that may be expected at a site. The RME concentration is designed to be higher than the concentration that will be experienced by most individuals in an exposed population. The RME concentration was calculated as the lesser of the maximum detected concentration or the 95 percent upper confidence limit (95UCL) on the arithmetic mean.

The average exposure scenario was evaluated to allow a comparison with the RME. The average exposure scenario is intended to be more representative of likely human exposures at the site. The average exposure point concentrations were calculated as an arithmetic mean of the chemical results for a particular medium.

In calculating exposure point concentrations, a value of one-half the sample quantitation limit was used for samples in which a particular chemical was not detected. This procedure is designed to avoid underestimating risks. To avoid overestimation, this procedure was not applied to samples with abnormally high quantitation limits. The approach used to screen unusually high detection limit data from the qualitative risk assessment consisted of first identifying detection limits that were elevated substantially above the typical detection limits for a given chemical and medium, and then eliminating those data with detection limits that exceeded the highest detected concentration by an order of magnitude or more. This approach eliminated few samples from the data set and provided more realistic exposure point concentrations.

Estimates of potential human intake of chemicals for each exposure pathway were calculated by combining exposure point concentrations with pathway-specific exposure assumptions (for parameters such as ingestion rate, body weight, exposure frequency, and exposure duration) for each medium of concern. Exposure parameters used in the risk assessment calculations were based on a combination of EPA Region 10 default values and site-specific exposure assumptions. More conservative exposure parameters were used to calculate RME chemical intakes than were used to calculate average intakes. The exposure parameters used at OU 5 are shown in Table 7.

Table 7
Exposure Parameters Used in Human Health Risk Assessment at OU 5

Exposure Pathway	Parameter	Units	Area 1		Area 52		Area 31		
			RME Scenario[a]	Reference	RME Scenario[a]	Reference	Average Scenario[a]	RME Scenario[a]	Reference
Dermal Contact with Soil/Sediment	Exposure Frequency	days/yr	NA		NA		Worker 50 (soil)	Worker 50 (soil)	BPJ
							Resident 275 (soil)	Resident 350 (soil)	BPJ
							Resident 10 (sediment)	Resident 20 (sediment)	BPJ
	Contact Rate	mg/cm3	NA		NA		Worker 1	Worker 1	BPJ
							Resident 0.6	Resident 1	BPJ
	Skin Surface Area	cm2					Worker 1,980	Worker 2,120	EFH 1989
							Resident 1,900	Adult resident 3,190 (soil)	
								Adult resident 5,000 (sediment)	
								Child resident 3,900 (sediment)	

Table 7 (Continued)
Exposure Parameters Used in Human Health Risk Assessment at OU 5

Exposure Pathway	Parameter	Units	Area 1		Area 52		Area 31		
			RME Scenario[a]	Reference	RME Scenario[a]	Reference	Average Scenario[a]	RME Scenario[a]	Reference
Soil/Sediment Ingestion	Exposure Frequency	days/yr	Child 2.08 Adult 250	BPJ RAGS 1989	Adult 250	RAGS 1989	Worker 50	Worker 50	BPJ
							Resident 275 (soil)	Resident 350 (soil)	BPJ
							Resident 10 (sediment)	Resident 20 (sediment)	BPJ
	Ingestion Rate	mg/day	Child 10 (sediment)	RAGS 1989			Worker 50	Worker 50	RAGS 1992
			Adult 50 (soil)	RAGS 1992	Adult 50 (soil)	RAGS 1992	Resident 275 (soil)	Resident 350 (soil)	BPJ
							Resident 10 (sediment)	Resident 20 (sediment)	BPJ
Dermal Exposure to Surface Water	Exposure Frequency	days/yr	NA		NA		Worker 50	Worker 50	BPJ
							Resident 10	Resident 20	BPJ
	Exposure Time	hours/day	NA		NA		Worker 4	Worker 4	BPJ
							Resident 1	Resident 1	BPJ
	Skin Surface Area	cm2	NA		NA		Worker 1,980	Worker 2,120	EFH 1989
							Resident 1,900	Resident 5,000	EFH 1989

Table 7 (Continued)
Exposure Parameters Used in Human Health Risk Assessment at OU 5

Exposure Pathway	Parameter	Units	Area 1		Area 52		Area 31		
			RME Scenario[a]	Reference	RME Scenario[a]	Reference	Average Scenario[a]	RME Scenario[a]	Reference
Incidental Ingestion of Surface Water	Exposure Frequency	days/yr	Child 2.98	BPJ	NA		NA	NA	
	Ingestion Rate	ml/day	50	BPJ	NA		NA	NA	
Inhalation of Soil Particulates	Exposure Frequency	days/yr	NA		NA		Worker 50	Worker 50	BPJ
							Resident 275	Resident 350	BPJ
	Inhalation Rate	m3/day	NA		NA		Worker 20	Worker 20	RAGS 1989
							Resident 20	Resident 20	
	Average Particulate Conc. (PM10)	kg/m3	NA		NA		5E-08	5E-08	Ambient Air Quality
Groundwater Ingestion	Exposure Frequency	days/yr	NA		NA		Worker NA	Worker NA	
							Resident 275	Resident 350	BPJ
	Ingestion Rate	l/day	NA		NA		Worker NA	Worker NA	
							Resident 1.4	Resident 2	RAGS 1989

Table 7 (Continued)
Exposure Parameters Used in Human Health Risk Assessment at OU 5

Exposure Pathway	Parameter	Units	Area 1 RME Scenario[a]	Area 1 Reference	Area 52 RME Scenario[a]	Area 52 Reference	Area 31 Average Scenario[a]	Area 31 RME Scenario[a]	Area 31 Reference
Dermal Exposure to Groundwater While Showering	Exposure Frequency	days/yr	NA		NA		Worker NA	Worker NA	
							Resident 275	Resident 350	BPJ
	Exposure Time	hrs/day	NA		NA		Worker NA	Worker NA	
							Resident 0.12	Resident 0.17	BPJ
	Skin Surface Area	cm2	NA		NA		Worker NA	Worker NA	
							Resident 20,000	Resident 20,000	EFH 1989
Inhalation of Volatiles From Groundwater	Exposure Frequency	days/year	NA		NA		Worker NA	Worker NA	
							Resident 275	Resident 350	BPJ
	Indoor Inhalation Rate	m3/day	NA		NA		Worker NA	Worker NA	
							Resident 15	Resident 15	EFH 1989
	Water to Air Conversion Factor (ACF)	l/m3	NA		NA		Worker NA	Worker NA	
							Resident 0.5	Resident 0.5	RAGS 1989

Table 7 (Continued)
Exposure Parameters Used in Human Health Risk Assessment at OU 5

Exposure Pathway	Parameter	Units	Area 1		Area 52		Area 31		
			RME Scenario[a]	Reference	RME Scenario[a]	Reference	Average Scenario[a]	RME Scenario[a]	Reference
All Pathways	Exposure Duration	years	Child 6	EFH 1989	Adult 25	RAGS 1989	Worker 25	Worker 25	
			Adult 25	RAGS 1989			Resident 9	Resident 30	RAGS 1989
								Adult 24	
								Child 6	
	Body Weight	kg	Child 38.5	Anderson 1985b	Adult 70	RAGS 1989	Adult 70	Adult 70	RAGS 1989
			Adult 70	RAGS 1989					
	Averaging Time Carcinogenic	days	25,550	RAGS 1989	25,550	RAGS 1989	2,550	25,550	RAGS 1989
	Averaging Time Noncarcinogenic	days	Child 2,190	RAGS 1989	Adult 9,125	RAGS 1989	Worker 9,125	Worker 9,125	RAGS 1989
			Adult 9,125				Resident 3,285	Resident 10,950	

[a]The average scenario and the RME scenario columns show the case (e.g., worker) and the exposure parameter (e.g., 50). The units in which the exposure parameters are expressed are shown in the third column.
[b]Anderson E.; N. Browne; J. Ramig; T. Warn, Development of Statistical Distributions or Ranges of Standard Factors Used in Exposure Assessments, U.S. Environmental Protection Agency, Exposure Assessment Group, Office of Health and Environmental Assessment. 1985.

Table 7 (Continued)
Exposure Parameters Used in Human Health Risk Assessment at OU 5

Notes:

BPJ	Best professional judgment
EFH 1989	Exposure Factors Handbook USEPA 1989
RAGS 1989	US EPA Risk Assessment Guidance for Superfund, Part A. (1989), Part B (1992)
RME	Reasonable maximum exposure

7.1.3 Toxicity Assessment

A toxicity assessment was conducted for the COPCs to quantify the relationship between the magnitude of exposure and the likelihood or severity of adverse effects (i.e., dose-response assessment). The toxicity assessment also weighed the available evidence regarding the potential for chemicals to have adverse effects on exposed individuals (i.e., hazard identification).

Toxicity values are used to express the dose-response relationship and are developed separately for cancer effects and noncancer effects. Toxicity values are derived from either epidemiological or animal studies to which uncertainty factors are applied. These uncertainty factors account for variability among individuals, as well as for the use of animal data to predict effects on humans. The primary sources of toxicity values are EPA's Integrated Risk Information System (IRIS) database and Health Effects Assessment Summary Tables (HEAST). Both IRIS and HEAST were used to identify the toxicity values used in the OU 5 risk assessment.

Toxicity values for cancer effects are referred to as cancer slope factors (CSFs). CSFs have been developed by the EPA for estimating excess lifetime cancer risks associated with exposure to potential cancer-causing chemicals (carcinogens). CSFs, which are expressed in units of 1/(mg/kg/day), or $(mg/kg/day)^{-1}$, are multiplied by the estimated daily intake of a potential carcinogen to provide an upper-bound estimate of the excess lifetime cancer risk associated with exposure at that intake level. The upper-bound estimate represents a conservative estimate of risk calculated from the CSF. This approach makes underestimation of the actual cancer risk highly unlikely.

Toxicity values for noncancer effects are referred to as reference doses (RfDs). RfDs, which are expressed in units of mg/kg/day, are estimates of acceptable lifetime daily exposures levels for humans, including sensitive individuals. Estimated intakes of COPCs (e.g., the amount of a chemical that might be incidentally ingested from soil) are compared with the RfD to assess risk.

Toxicity values are only available for the oral and inhalation pathways. The EPA has not published toxicity values for dermal contact exposures and recommends using the oral toxicity values to evaluate the dermal pathway. In calculating chemical intakes for dermal exposures, the oral values are adjusted by an absorption factor, which corrects for the percentage of the chemical that is absorbed through the skin (compared with direct oral ingestion).

The EPA does not currently provide a toxicity value for lead because of its unique toxicity characteristics. As an alternative to the traditional risk assessment approach, the EPA has published recommended acceptable screening levels for lead. At the time of the baseline risk assessment for Area 31, these levels were 500 mg/kg for soil and 15 μg/L for drinking water. The recommended lead levels for the screening risk assessment for Area 1 and Area 52 were 400 mg/kg for soil and 15 μg/L for drinking water. Lead concentrations at these sites were compared with the respective recommended lead levels to determine risks from lead.

Petroleum hydrocarbons were detected in soil at Area 31 above the MTCA Method A cleanup level for TPH in soil. Whereas a toxicity value for TPH is not available in IRIS or HEAST, the EPA has developed provisional RfDs for TPH-JP-5 and TPH-gasoline. Petroleum is a complex mixture of hydrocarbons, many of which can contribute to detectable TPH concentrations. The provisional RfD for TPH-JP-5 was used to evaluate potential risks at Area 31 because this would have been the most commonly used fuel at the site.

7.1.4 Risk Characterization

A risk characterization was performed to estimate the likelihood of adverse health effects in potentially exposed populations. The COPCs were evaluated in the risk characterization to determine if any of the COPCs pose unacceptable risk to human health. Those that pose unacceptable risk are considered COCs.

The risk characterization combines the information developed in the exposure assessment and toxicity assessment to calculate risks for cancer and noncancer effects. In the focused human health risk assessments for Area 1 and Area 52, the risk characterization involved comparing detected concentrations of COPCs against the site-specific RBSCs to determine if the potential for risk existed and what the general magnitude of the risk might be. In the baseline human health risk assessment for Area 31, the risk characterization determined quantitative risk estimates for each chemical in each medium. Because of fundamental differences in the mechanisms through which carcinogens and noncarcinogens act, risks were characterized separately for cancer and noncancer effects. The discussions below explain how the results of the risk characterization are expressed.

Areas 1 and 52

In the focused risk assessment, the potential for significant noncancer health effects or unacceptable lifetime cancer risks was evaluated by comparing detected concentrations of COPCs against the site-specific RBSCs. The exposure assumptions used to develop the site-specific RBSCs were discussed in Section 7.1.2. The target risk levels for the site-specific RBSCs were an HQ equal to 0.1 and a carcinogenic risk of 1.0×10^{-7}. Chemicals detected at concentrations below the RBSCs were determined to pose no significant risk. Conversely, chemicals detected at concentrations greater than the RBSCs were assigned a potentially unacceptable risk and were considered COCs.

Area 31

In the baseline human health risk assessment, the noncancer and cancer risks were evaluated separately.

Noncancer Risks. The potential for adverse noncancer effects from a single chemical in a single medium is expressed as an HQ, which is calculated by dividing the average daily chemical intake derived from the chemical concentration in the particular medium by the RfD for the chemical. The RfD is a dose below which no adverse health effects are expected to occur. An HQ less than 1.0 is considered acceptable by the EPA.

By adding the HQs for all chemicals within a medium and across all media to which a given population may reasonably be exposed, a hazard index (HI) can be calculated. The HI represents the combined effects of all the potential exposures that may occur for the exposure scenario being evaluated. An HI less than 1.0 is considered acceptable by the EPA. Chemicals that contributed significantly to an HI greater than 1.0 were considered COCs.

Cancer Risks. The potential health risks associated with carcinogens is estimated by calculating the increased probability of an individual developing cancer during his or her lifetime as a result of exposure to a carcinogenic substance. Excess lifetime cancer risks are calculated by multiplying the CSF by the daily chemical intake averaged over a lifetime of 70 years.

These cancer risk estimates are probabilities that are expressed as a fraction less than 1.0. For example, an excess lifetime cancer risk of 0.000001 (or 10^{-6}) indicates that, as a plausible upper-bound estimate, an individual has a one-in-one-million chance of developing cancer as a result of site-related exposure to a carcinogen over a 70-year lifetime under the specific exposure conditions at the site. An excess lifetime cancer risk of 0.0001 (or 10^{-4}) represents a one-in-ten-thousand chance. The EPA recommends in the NCP a target cancer risk range of 0.000001 to 0.0001 (or 10^{-6} to 10^{-4}) for CERCLA sites (40 CFR 300). Chemicals that contributed to a cancer risk greater than 1.0×10^{-5} were considered COCs.

7.1.5 Results

Areas 1 and 52

For Area 1 and Area 52, the screening level risk assessment found no potential for significant human health risks, and no human health COCs were defined.

Area 31

For Area 31, the baseline risk assessment found potential human health risks. Table 8 summarizes the results of the risk assessment for each exposure scenario. This risk assessment is based on the Phase I and Phase II environmental data, summarized in Table 4. Analytical results from groundwater samples collected at MW31-9A were not included in the risk assessment, because it was assumed that a drinking water well would not be installed where there was floating petroleum product and that there would be a clear human health risk if such a well were installed.

No cancer risks in excess of 1.0×10^{-4} were identified for any of the scenarios evaluated. The cancer risks for all of the scenarios fell within the 10^{-6} to 10^{-4} target range of risks of potential concern. The RME cancer risks for future residents were near the upper end of the target risk range. Cancer risks for both current worker scenarios and the average future resident scenario were near the lower end of the target risk range.

The potential noncancer risk for the future residential scenario at Area 31 exceeded an HQ of 1.0 for manganese in groundwater.

The reasonable maximum exposure for lead for Area 31 indicates that there is not a significant human health risk from exposure to lead in soils or groundwater. However, lead was detected in one sediment sample (834 mg/kg lead) and one ash sample (544 mg/kg lead) at levels that exceed the EPA soil action level of 500 mg/kg and the MTCA A level of 250 mg/kg. The ash sample was collected from the ash pile southwest

Table 8
Summary of Potential Human Health Risks and COCs at Area 31

Exposure Scenario	RME Cumulative Risk	Chemicals of Concern in Specific Media	
		Soil	Groundwater
Current On-Site Worker			
Reasonable maximum exposure—noncancer	HI < 1.0	NA	NE
Reasonable maximum exposure—cancer	CR = 2.0×10^{-6}	Dioxins/furans, PAHs	NE
Average exposure—noncancer	HI < 1.0	NA	NE
Average exposure—cancer	CR = 2.0×10^{-6}	Dioxins/furans, PAHs	NE
Future Resident			
Reasonable maximum exposure—noncancer	HI = 6.3	NA	Manganese
Reasonable maximum exposure—cancer	CR = 6.0×10^{-5}	Dioxins/furans, PAHs, PCBs	Dioxins/furans
Average exposure—non-cancer	HI = 3.5	NA	Manganese
Average exposure—cancer	CR = 3.0×10^{-6}	Dioxins/furans, PAHs	Dioxins/furans

Notes:
CR Cancer risk
HI Hazard index
NA Not applicable. No chemicals in this medium pose significant risk.
NE Groundwater was not evaluated as an exposure pathway under the current on-site worker scenario.
PAHs Polycyclic aromatic hydrocarbons
PCBs Polychlorinated biphenyls

of the underground storage tank and the surface sediments from the ditch that borders the ash pile. The samples collected in this area are the only samples found to exceed recommended guidelines. Therefore, this area is identified as a "hot spot" where there may be a potential human health risk due to contact with the ash material or the ditch surface sediments.

Also, although numeric risk estimates were not made based on samples from the monitoring well that contained floating petroleum product, the petroleum would present a risk if a drinking water well were installed at Area 31.

In summary, based on Phase I and Phase II data, manganese in groundwater and floating petroleum product in Area 31 groundwater pose potentially unacceptable human health risks if groundwater is used as a source of drinking water. Lead concentrations in an isolated area of ash and adjacent sediment could pose potential human health risks.

Additional groundwater sampling occurred after the risk assessment was completed. During groundwater sampling in 1995 in Area 31, five additional organic chemicals were identified as COCs (chloroform, 1,2-dichloroethane, styrene, vinyl chloride, and pentachlorophenol). The maximum detected groundwater concentrations for these five chemicals are compared to the EPA Region 10 groundwater RBSCs (which are set at 10^{-6} carcinogenic risk) in Table 9. Three of the five chemicals significantly exceed the RBSC, indicating that the groundwater cancer risk may be greater than 1.0E-04 in the locations of these exceedances. However, the exceedances occurred immediately downgradient (within 50 feet) of the oil/water separator and floating petroleum product plume, where there is already a presumed risk because of the presence of floating petroleum product.

Table 9
Maximum Detected Groundwater Concentrations (Area 31) Compared With Default Groundwater RBSCs for Chemicals Not Included in 1992 Baseline HHRA

Chemical	Maximum Detected Concentration µg/L	EPA Region 10 Groundwater RBSC µg/L
Chloroform	5	0.275
1,2-Dichloroethane	0.8	0.197
Styrene	2	2.27
Vinyl chloride	4	0.0282
Pentachlorophenol	7	0.00071

7.1.6 Uncertainty

The accuracy of the risk assessment depends on the quality and representativeness of the data and assumptions that are used. The baseline risk assessment is primarily a decisionmaking tool for use in assessing the need for remedial action. The results of a baseline risk assessment are presented in terms of the potential for adverse effects based on a number of very conservative assumptions. The tendency to be conservative is an effort to err on the side of protection of human health.

Uncertainty Associated With Toxicity Assessment

Uncertainties associated with the toxicity assessment are the same for both the focused and baseline risk assessments.

For carcinogens, CSFs for probable or possible human carcinogens are given the same weight as known human carcinogens. CSFs derived from animal data are equally weighted with those derived from human data. Uncertainties in the combined risks are also compounded because CSFs for various chemicals do not have equal accuracy or levels of confidence and are not based on the same severity of effect. These factors may result in an overestimation or underestimation of risk. Because CSFs typically correspond to the 95UCL of the mean probability of carcinogenic response (i.e., upper-bound estimates), CSFs are inherently overly conservative. In addition, the assumption that any exposure to a carcinogen poses some degree of risk is unproven, and it is possible that low levels of some carcinogens may not actually pose any risk at all.

Because chemical-specific toxicity data are limited for most carcinogenic PAH compounds, the CSF for benzo(a)pyrene was used as a surrogate for all PAH compounds that are classified as probable human carcinogens. Because benzo(a)pyrene may be the most potent carcinogenic PAH, this practice may overestimate risks.

For noncarcinogens, RfDs for different chemicals have varying degrees of confidence associated with them because of variations in the amount and quality of toxicity information and the uncertainty and modifying factors used in developing them. For example, an HQ greater than 1.0 for a chemical with an RfD that incorporates a high uncertainty and was derived from data of questionable quality may be of less concern than the same HQ for a chemical with a better-defined RfD.

A variety of chemicals were detected during the RI for which toxicity values are not available. For example, toxicity data (RfDs) are not available for lead and only provisional toxicity data are available for petroleum hydrocarbons; therefore, they were excluded from the HI calculations. Their exclusion may result in an underestimation of the noncancer risks.

Risk associated with dermal contact with soil and sediment was not evaluated for VOCs because competition between volatilization and absorption is expected to make dermal absorption minimal. There is moderate to high uncertainty regarding the methodology and absorption rates used for the dermal pathway, especially for exposures to water. Dermal absorption values used for soil and sediment are not chemical-specific but are based on chemical class. Dermal absorption is dependent on the amount of time the skin is in direct contact with a chemical. Therefore, an exposure parameter that incorporates time is needed to estimate dermal intake of a chemical. However, the method of estimating dermal absorption from soil and sediment does not consider the duration of contact, increasing the uncertainty associated risk estimates for dermal absorption.

Uncertainty Associated With Exposure Assessment

For both the screening level and baseline risk assessments, conservative approaches were used to select potential current and future receptors and exposure pathways to be used in calculating risks. At Area 31, current worker, recreational, and future residential receptors were evaluated. Very little, if any, on-site worker exposure currently occurs at Area 31, and recreational and residential exposures may never occur unless the base is closed and the area is developed for residential use. At Area 1, a recreational (child visitor) scenario was evaluated, and at Areas 1 and 52, an industrial worker scenario was evaluated. In all cases, the frequency and duration of exposure that were assumed in order to derive the site-specific RBSCs were conservative. Industrial worker exposure at Area 1 may never occur unless the landfill is developed in the future.

Exposure point concentrations of chemicals at the site were assumed to remain constant for the entire exposure duration. No degradation or other natural losses of chemicals (e.g., migration or dilution) were assumed to occur. The assumption of a static chemical concentration for the entire exposure duration introduces a conservative bias for chemicals that undergo environmental degradation, migration, or immobilization.

In the Area 31 baseline risk assessment, many of the exposure assumptions are default values in EPA Region 10 guidance. The RME parameters used to evaluate exposures are intentionally conservative to ensure that site risks are not underestimated. In recognition of this, the EPA Region 10 guidance specifies that average exposures are also to be quantified. Exposures differed significantly between the average and RME scenario. Most exposure parameters used in the RME scenario were overestimates, whereas parameters for the average exposure scenario were more representative of typical exposures.

Uncertainty Associated With Risk Characterization

In the focused risk assessment for Areas 1 and 52, the site-specific RBSCs were compared against the maximum detected concentrations of chemicals on site. While useful as a screening procedure to eliminate chemicals, this may overestimate any actual exposure that would occur on a regular basis at the site.

In the baseline risk assessment for Area 31, RME and average risks were calculated. Because the RME scenario is designed to represent the upper-bound estimate of probable exposure and is intentionally conservative, RME risk estimates may be overestimates. Average risks may be more realistic but are still expected to represent conservative risk estimates for a typical receptor. Cancer and noncancer risks are summed in the risk characterization process to estimate potential risks associated with the simultaneous exposure to multiple chemicals. The assumption that risks from exposure to multiple chemicals are additive does not address potential synergistic (greater than additive) or antagonistic (less than additive) interactions.

In summary, the probability that human health risks were underestimated is low, and the likelihood that risks were overestimated is high. Estimated future risks are highly uncertain for the following reasons: (1) future land use assumptions are hypothetical (i.e., exposure may never occur), and (2) the magnitude of future exposure-point concentrations is unknown.

7.2 ECOLOGICAL RISK ASSESSMENT

A habitat assessment and focused ecological risk assessment were conducted for Area 1. A qualitative assessment was conducted for Area 52, and a quantitative ecological risk assessment was conducted for Area 31. The methods used and the major conclusions of these assessments are summarized in the following subsections.

7.2.1 Area 1

The habitat assessment and focused ecological risk assessment were performed to evaluate the current status of the habitats in Area 1. The overall risk assessment methodology compared the maximum detected chemical concentrations to ecological RBSCs and background concentrations. The three media investigated were surface soil, surface water (in the wetlands and storm sewer), and freshwater sediment.

Methods

Habitat Assessment. Two qualitative biological surveys of the beach and intertidal zone were performed at Area 1, the first on August 5, 1994, by URS, and the second on May 15, 1995, by the EPA and URS. Comparison of the results of the two surveys shows a large degree of similarity in the species observed. Because marine biologists from two different organizations have identified essentially the same species and certainly the same major taxonomic groups during two different surveys, it is likely that the most abundant taxa have been cataloged. Neither survey attempted to quantify species abundance.

Focused Ecological Risk Assessment. Because the ecological risk assessment was developed at a screening level, the approach varied from the four-part procedure (data evaluation, exposure assessment, toxicity assessment, risk characterization) found in most quantitative assessments. The approach used for this focused risk assessment was to compare maximum detected chemical concentrations found in Area 1 with conservative, media-specific ecological RBSCs. Chemicals exceeding their respective RBSCs and background concentrations were considered COCs. Ecological assessment and measurement endpoints were not used in this approach.

RBSC Selection for Surface Water. Freshwater RBSCs were selected to be highly protective of a wide variety of aquatic organisms. They were obtained from a number of sources and selected according to the following hierarchy:

(1) Freshwater chronic ambient water quality criteria (AWQC) (U.S. EPA 1991)

(2) Freshwater chronic lowest-observed-effects level (LOEL) (U.S. EPA 1991)

(3) The lower of either the marine chronic AWQC or 0.2 times the freshwater acute AWQC (U.S. EPA 1990)

(4) 0.2 times the freshwater acute LOEL (U.S. EPA 1991)

(5) The lowest chronic LOEL available from the aquatic toxicity literature

(6) 0.2 times the marine acute AWQC (U.S. EPA 1991)

(7) 0.04 times an LC_{50} or other lethal endpoint

RBSC Selection for Freshwater Sediment. Freshwater sediment RBSCs were selected to be highly protective of a wide variety of aquatic organisms. RBSCs for freshwater sediment were obtained from a variety of sources and selected according to the following hierarchy:

(1) Effects range-low (ER-L) (Long and Morgan 1990)

(2) Marine sediment quality standards (SQS) (WAC 173-204-320)

(3) Equilibrium partitioning (EqP) for non-ionic organic chemicals (Di Toro et al. 1991)

RBSC Selection for Soil. Two methods were used to determine RBSCs in soil—one for organic compounds and one for inorganic substances. For organic compounds, a model-based approach was used. Potential exposure was estimated by using a model for maximally exposed surrogate vertebrate species. The species selected was the masked shrew (*Sorex cinereus*), which is exposed to soil-borne chemicals through the ingestion of soil and earthworms. That maximum dose was then compared with a conservative toxicity value to calculate a chemical-specific RBSC. The same model-based approach was evaluated for calculating RBSCs for inorganic substances; however, the resultant RBSCs were 0.14 to 0.02 times the average concentrations of the respective elements in soils of the United States. Therefore, the model-based approach was found unsuitable and a substitute approach was employed. For inorganic substances, RBSCs were developed by reviewing soil invertebrate and plant toxicity information. The database comprised 108 toxicity values for 17 inorganic substances. The most conservative published toxicity value was selected as the RBSC for inorganic substances.

Detected concentrations of inorganic chemicals were also compared with background concentrations. Whereas a small percentage of sediments represents fluvial deposits, in general the material sampled as sediment represents soil from the fill material placed over the landfill and not sediments transported and reworked by fluvial processes (as would usually be the case). Background concentrations for soil were used. No background concentrations are available for surface water.

To potentially pose an ecological concern, the chemicals must exceed both ecological RBSCs and, where background concentrations are available, the background concentrations.

Results

Habitat Description. Area 1 comprises three habitat types: (1) an approximately ¼-acre wetland area, characterized as a marsh or swamp, (2) a drainage ditch about 100 feet long that drains the wetland, and (3) an approximately 6-acre upland covered landfill. The wetland and drainage ditch have two sources: groundwater discharge and runoff from a storm sewer draining Saratoga Street and Princeton Street along the western edge of the base (Figure 2). The wetland usually contains saturated soil, but it may contain surface water during the late fall and winter when precipitation is high. It is covered by grasses and rushes. Flows in the drainage ditch are intermittent in response to precipitation events; therefore, it is unlikely to provide habitat suitable for aquatic species. Except when the drainage ditch carries runoff during precipitation periods, its habitat type resembles the upland habitat of the remainder of Area 1. This area is not considered a critical habitat for endangered species.

The upland area is covered by 3 to 4 feet of soil fill that supports introduced low-lying grasses. Birds using the area include killdeer (observed with chicks), northern harriers (marsh hawks), swallows, meadowlarks, and sea gulls. An eagle roost has been cataloged about 1 mile south of Area 1 on a headland point, and eagles have been observed at Area 1. Rabbits and a small ground mammal (probably a shrew or a mole) have been observed at Area 1.

The beach and intertidal benthic environment below Area 1 is a high-energy environment with no cover or topographic relief. It does not provide particularly good habitat for most species of marine life. Most of the beach consists of cobbles covered by sand. The approximately 10-foot-high bluff area of the landfill that exists along the length of the beach is above the high-tide line and unavailable to marine species, except for those that can live in the splash zone above the high-tide line. The lack of relief means that no tide pool habitat is available at the beach below Area 1, although a few small tide pools exist to the south of Area 1. Seven species of marine algae have been identified in the intertidal benthic environment of Area 1. Predominant species of marine algae include sea lettuce (*Ulva fenestrata*), bull kelp (*Nereocystis luetkeana*), and wing kelp (*Alaria marginata*). Twelve species of marine invertebrates have also been observed. Predominant species of marine invertebrates include acorn barnacles (*Balanus glandula*) attached to rocky substrate, and sand fleas (*Traskorchestia traskiana*), amphipods that dwell in piles of drying algae at the high-tide line.

Four bird species have been identified on the beach: killdeer (*Charadrius vociferus*), glaucous-winged gulls (*Larus glaucescens*), Heermann's gulls (*Larus heermanni*), and northwestern crows (*Corvus caurinus*).

Focused Ecological Risk Assessment. Table 10 presents the results of the focused ecological risk assessment for Area 1. In soil, seven chemicals (all inorganics) were detected at concentrations exceeding the RBSCs: cobalt, copper, cyanide, lead, manganese, nickel, and zinc. In surface water, 10 chemicals were detected at concentrations exceeding the RBSCs: Aroclor 1254, Aroclor 1260, cadmium, chromium, copper, bis(2-ethylhexyl)phthalate, mercury, 2-methylnaphthalene, vanadium, and zinc. In sediment, six chemicals, a majority of those detected, exceeded the RBSCs: Aroclor 1254, copper, bis(2-ethylhexyl)phthalate, lead, nickel, and zinc. With the exceptions of beryllium and selenium, all of the inorganic chemicals detected in soil exceeded their respective background concentrations. With the exception of beryllium, cobalt, and manganese, all of the inorganic chemicals detected in sediments exceeded their respective background concentrations.

The Whidbey Island background concentration for manganese in soil substantially exceeds the RBSC for sediment, whereas the maximum manganese concentration detected in sediment at Area 1 only slightly exceeded the RBSC. Given this relatively high background concentration, it would be likely for the concentration of manganese to exceed the corresponding RBSC.

Five chemicals in surface water (barium, cobalt, acetone, carbon disulfide, and 4-methylphenol) and five chemicals in sediment (barium, beryllium, cobalt, vanadium, and acetone) do not have ecological RBSCs because of a lack of toxicity information. Therefore, potential risks may be underestimated.

Cyanide was detected twice in three groundwater samples. The concentrations were 25.8 μg/L at MW-18 and 152.0 μg/L at MW-103. A duplicate sample was collected from MW-103, and cyanide was not detected at a level above the detection limit of 10 μg/L. The marine acute ambient water quality criterion for cyanide is 1.0 μg/L, suggesting a

Table 10
Ecological Risk-Based Screening Summary at Area 1

Compound	Soil					Surface Water			Sediment				
	Maximum Concentration (mg/kg)	Whidbey Background (mg/kg)	Exceeds Background	RBSC (mg/kg)	Exceeds RBSC	Maximum Concentration (µg/L)	RBSC (µg/L)	Exceeds RBSC	Maximum Concentration (mg/kg)	Whidbey Background (mg/kg)	Exceeds Background	RBSC (mg/kg)	Exceeds RBSC
Aluminum	28,700	17,576	Yes	NA	NA	65.0	87.000	No	ND	ND	ND	ND	ND
Antimony	ND	8.16	No	NA	NA	5.20	30.000	No	ND	ND	ND	ND	ND
Arsenic	12.1	7.54	Yes	100.0	No	28.1	190.000	No	10.6	7.54	Yes	33.0	No
Barium	147	98.3	Yes	3,300	No	545	NA	NA	101	98.3	Yes	NA	NA
Beryllium	0.51	0.52	No	60.0	No	1.30	5.300	No	0.240	52.0	No	NA	NA
Cadmium	4.20	0.83	Yes	9.00	No	10.8	1.100	Yes	3.30	0.83	Yes	5.00	No
Chromium	72.5	43.3	Yes	1,100	No	175	11,000	Yes	53.2	43.3	Yes	80.0	No
Cobalt	23.2	17.1	Yes	20.0	Yes	58.4	NA	NA	12.4	17.1	No	NA	NA
Copper	156	44.2	Yes	50.0	Yes	476	12.0	Yes	133	44.2	Yes	70.0	Yes
Cyanide	0.680	—	—	0.33	Yes	ND	ND	ND	ND	—	—	ND	ND
Lead	186	15.6	Yes	34.0	Yes	1.39	3.20	No	676	15.6	Yes	35.0	Yes
Manganese	1,320	681	Yes	1,200	Yes	8.91	100.0	No	475	681	No	460	Yes
Mercury	ND	ND	ND	ND	ND	0.43	0.012	Yes	ND	ND	ND	ND	ND
Nickel	219	68.8	Yes	170	Yes	30.4	160	No	89.4	68.8	Yes	30.0	Yes
Selenium	0.360	0.430	No	10.0	No	ND	ND	ND	ND	ND	ND	ND	ND
Silver	1.50	1.07	Yes	2.00	No	ND	ND	ND	ND	ND	ND	ND	ND
Thallium	0.650	0.250	Yes	10.0	No	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	93.8	53.7	Yes	910	No	203	41.0	Yes	54.5	53.7	Yes	NA	NA
Zinc	336.0000	100	Yes	67.0	Yes	2,570	110	Yes	308	100	Yes	120	Yes
Acetone	ND	ND	ND	ND	ND	11.0	NA	NA	0.020	ND	ND	NA	ND
Aldrin	0.0001	—	—	0.01	No	ND	ND	ND	ND	ND	ND	ND	ND

Table 10 (Continued)
Ecological Risk-Based Screening Summary at Area 1

Compound	Soil					Surface Water			Sediment				
	Maximum Concentration (mg/kg)	Whidbey Background (mg/kg)	Exceeds Background	RBSC (mg/kg)	Exceeds RBSC	Maximum Concentration (µg/L)	RBSC (µg/L)	Exceeds RBSC	Maximum Concentration (mg/kg)	Whidbey Background (mg/kg)	Exceeds Background	RBSC (mg/kg)	Exceeds RBSC
Aroclor 1016	0.0047	—	—	0.03	No	ND	ND	ND	ND	—	—	ND	ND
Aroclor 1254	0.0170	—	—	0.03	No	2.50	0.014	Yes	0.830	—	—	0.05	Yes
Aroclor 1260	0.0260	—	—	0.19	No	0.99	0.014	Yes	ND	—	—	ND	ND
Benzene	0.0090	—	—	0.41	No	ND	ND	ND	ND	—	—	ND	ND
Benzo(a)anthracene	0.0320	—	—	40.0	No	1.00	60.0	No	ND	—	—	ND	ND
Benzo(b)fluoranthene	0.0800	—	—	48.0	No	1.00	60.0	No	ND	—	—	ND	ND
Benzo(k)fluoranthene	0.0640	—	—	51.0	No	1.00	60.0	No	ND	—	—	ND	ND
Benzoic acid	—	—	ND	ND	ND	ND	ND	ND	0.110	—	—	0.65	No
Benzo(g,h,i)perylene	0.0650	—	—	51.0	No	1.00	60.0	No	ND	—	—	ND	ND
Benzo(a)pyrene	0.0540	—	—	48.0	No	1.00	60.0	No	ND	—	—	ND	ND
Butyl benzyl phthalate	—	—	ND	ND	ND	1.00	3.00	No	ND	—	—	ND	ND
Carbon disulfide	—	—	ND	ND	ND	9.00	NA	NA	ND	—	—	ND	ND
alpha-Chlordane	0.00007	—	—	0.77	No	ND	ND	ND	ND	—	—	ND	ND
gamma-Chlordane	0.00028	—	—	0.77	No	ND	ND	ND	ND	—	—	ND	ND
Chrysene	0.0350	—	—	35.0	No	1.00	60.0	No	ND	—	—	ND	ND
p-Cresol (4-methylphenol)	—	—	ND	ND	ND	1.00	NA	NA	ND	—	—	ND	ND
4,4'-DDD	0.0300	—	—	17.0	No	ND	ND	ND	ND	—	—	ND	ND
4,4'-DDE	0.0170	—	—	7.00	No	ND	ND	ND	ND	—	—	ND	ND
4,4'-DDT	0.0110	—	—	0.03	No	ND	ND	ND	ND	—	—	ND	ND

Table 10 (Continued)
Ecological Risk-Based Screening Summary at Area 1

	Soil					Surface Water			Sediment				
Compound	Maximum Concentration (mg/kg)	Whidbey Background (mg/kg)	Exceeds Background	RBSC (mg/kg)	Exceeds RBSC	Maximum Concentration (µg/L)	RBSC (µg/L)	Exceeds RBSC	Maximum Concentration (mg/kg)	Whidbey Background (mg/kg)	Exceeds Background	RBSC (mg/kg)	Exceeds RBSC
Di-n-butylphthalate	0.1400	—	—	37.0	No	ND	ND	ND	ND	—	—	ND	ND
Diethylphthalate	ND	—	—	ND	ND	1.00	3.00	No	ND	—	—	ND	ND
Di-n-octylphthalate	0.480	—	—	120	No	ND	ND	ND	0.061	—	—	0.58	No
Endrin	0.0004	—	—	0.01	No	ND	ND	ND	ND	—	—	ND	ND
Endrin aldehyde	0.00028	—	—	0.01	No	ND	ND	ND	ND	—	—	ND	ND
Endrin ketone	0.0013	—	—	0.01	No	ND	ND	ND	ND	—	—	ND	ND
Ethylbenzene	0.0050	—	—	56.0	No	ND	ND	ND	ND	—	—	ND	ND
bis(2-Ethylhexyl)phthalate	1.10	—	—	25.0	No	6.00	3.00	Yes	2.00	—	—	0.47	Yes
Fluoranthene	0.0320	—	—	48.0	No	1.00	60.0	No	ND	—	—	ND	ND
Heptachlor	0.0001	—	—	0.04	No	ND	ND	ND	ND	—	—	ND	ND
Heptachlor epoxide	0.0013	—	—	0.60	No	ND	ND	ND	ND	—	—	ND	ND
alpha-Hexachlorocyclohexane	0.0001	—	—	1.00	No	ND	ND	ND	ND	—	—	ND	ND
Indeno(1,2,3-c,d)pyrene	0.0440	—	—	21.0	No	1.00	60.0	No	ND	—	—	ND	ND
Isopropylacetone	0.0010	—	—	NA	NA	ND	ND	ND	ND	—	—	ND	ND
Methoxychlor	0.0017	—	—	2.10	No	ND	ND	ND	ND	—	—	ND	ND
2-Methylnaphthalene	ND	—	—	ND	ND	45.0	24.0	Yes	ND	—	—	ND	ND
Naphthalene	ND	—	—	ND	ND	8.00	620	No	ND	—	—	ND	ND
Phenanthrene	0.0200	—	—	42.0	No	1.00	60.0	No	ND	—	—	ND	ND
Picric acid	0.0031	—	—	10.0	No	ND	ND	ND	ND	—	—	ND	ND

Table 10 (Continued)
Ecological Risk-Based Screening Summary at Area 1

Compound	Soil					Surface Water			Sediment				
	Maximum Concentration (mg/kg)	Whidbey Background (mg/kg)	Exceeds Background	RBSC (mg/kg)	Exceeds RBSC	Maximum Concentration (µg/L)	RBSC (µg/L)	Exceeds RBSC	Maximum Concentration (mg/kg)	Whidbey Background (mg/kg)	Exceeds Background	RBSC (mg/kg)	Exceeds RBSC
Pyrene	0.0540	—	—	46.0	No	1.00	60.0	No	ND	—	—	ND	ND
Toluene	0.0020	—	—	240	No	ND	ND	ND	ND	—	—	ND	ND
Xylene	0.0350	—	—	8.50	No	ND	ND	ND	ND	—	—	ND	ND

Notes:

	Chemical of concern
—	Background concentration for organics is assumed zero
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
NA	Not available
ND	Not detected
RBSC	Risk-based screening concentration

potential impact to intertidal organisms if exposed to concentrations found in groundwater. However, a high-energy beach and intertidal habitat is present along the interface of Area 1 and the strait. Cyanide is probably attenuated to a moderate degree when moving from the inland monitoring wells to the discharge point in the intertidal zone. In addition, cyanide released into marine waters has low persistence because it is readily volatilized and degraded. Therefore, it is unlikely that cyanide entering Puget Sound in groundwater from Area 1 would affect pelagic (open water) marine organisms. The field inspection of the intertidal zone off Area 1 did not show any signs of impact to marine life. While the field inspections were limited in scope and were not intended to take the place of a bioassay, the field inspections provided a limited qualitative review, which was deemed appropriate given the conditions at the site.

Groundwater discharges into the intertidal zone. The RME concentration of cyanide, based on three samples from two locations, is 152 μg/L. Actual concentrations of cyanide in the intertidal zone may be much lower, as a result of dilution and contaminant loss mechanisms. However, groundwater seeps in the intertidal zone have not yet been analyzed for cyanide.

If cyanide concentrations in the intertidal zone exceed the ambient water quality criterion for cyanide (1.0 μg/L), certain sensitive intertidal species may be at risk. The limited biological survey found that normal communities of plants and animals are present in the Area 1 and Area 52 intertidal zone, with no apparent adverse visual effects. Because this is a high-energy beach, the existing intertidal species are limited to marine algae, barnacles, sand fleas, etc. If cyanide were to affect the intertidal species, the reduced populations of intertidal species could cause other species that feed on the intertidal species to forage for their food at other locations. Bioaccumulation of cyanide in animals at higher trophic levels is not expected, and thus risks to higher trophic level organisms are not quantifiable, but are expected to be minimal.

Summary and Conclusions

In soil, seven chemicals exceeded both background concentrations and ecological RBSCs: cobalt, copper, cyanide, lead, manganese, nickel, and zinc. Concentrations of cobalt, manganese, and nickel exceeded the RBSCs in only 1 of 14 soil samples. The 95UCL for cobalt (14.2 mg/kg), manganese (703 mg/kg), and nickel (87.6 mg/kg) did not exceed the ecological RBSCs (i.e., 20 mg/kg for cobalt, 1,200 mg/kg for manganese, and 170 mg/kg for nickel), suggesting that the maximum detected concentrations used in the risk assessment were not representative of the entire 6-acre landfill. In addition, concentrations exceeding RBSCs were found at depths not available to mammals and birds. For example, cobalt and manganese were detected at 5 to 6.5 feet bgs and nickel was detected from 0 to 8 feet bgs. Therefore, cobalt, manganese, and nickel detected in soil in Area 1 do not pose unacceptable ecological risks.

Concentrations of copper, cyanide, lead, and zinc exceeded the soil RBSCs in greater than 10 percent of the samples collected and their 95UCLs also exceeded the RBSCs. This evidence suggests that the aerial extent of the RBSC exceedances is of potential ecological concern. However, because the majority of soil samples were from depths below 2 feet, the maximum detected concentrations in soils are not representative of actual exposures that ecological receptors might receive. Also, exceedances for these four chemicals should be reviewed in relation to the degree of uncertainty associated with the ecological RBSCs.

Ecological RBSCs are based on the lowest reasonable toxicity value found in the published literature. Terrestrial ecological RBSCs for copper, lead, and zinc in soil were based on toxicity values for plants and soil-dwelling invertebrates. The relevance of these values at this site to higher trophic levels, such as mammals and birds, is unknown. Plants and invertebrates have different sensitivities to chemicals than those of birds and mammals. Therefore, it is difficult to make conclusive inferences about impacts to components of the terrestrial ecosystem of concern (e.g., mammals and birds) using ecological RBSCs that are based on plant and soil-dwelling invertebrate toxicity values.

The ecological RBSC for cyanide in soil was estimated using a food-chain model for the masked shrew. This model estimates potential exposure to soilborne chemicals through the ingestion of soil and prey (e.g., earthworms) and compares that dose to a suitable mammalian toxicity value. The chemical concentration in earthworms is estimated using published bioaccumulation factors (BAFs). No chemical-specific BAF was available for cyanide. Therefore, a default BAF (3.03) that was developed for non-ionic organic chemicals was used. Cyanide is a highly soluble ionic organic chemical that is readily metabolized by animals. A BAF of 3.03 probably overestimates the potential for cyanide to accumulate in earthworms. Because cyanide concentrations in soil at Area 1 only slightly exceeded the RBSC of 0.33 mg/kg (four of eight samples exceeding the RBSC ranged from 0.39 to 0.68 mg/kg), it is concluded that potential ecological impacts from cyanide at Area 1 are unlikely.

Ten chemicals in surface water (Aroclor 1254, Aroclor 1260, cadmium, chromium, copper, bis[2-ethylhexyl]phthalate, mercury, 2-methylnaphthalene, vanadium, and zinc) and six chemicals in sediment (Aroclor 1254, copper, bis[2-ethylhexyl]phthalate, lead, nickel, and zinc) exceeded background concentrations and RBSCs. The degree of exceedance for some chemicals was more than an order of magnitude (e.g., lead in sediment exceeded the background concentration by a factor of 45 and exceeded the RBSC by a factor of 19), suggesting the potential for ecological impacts to specific organisms inhabiting the small wetland. However, because the wetland is small and surface water is not permanent, organisms contacting surface water and sediment are limited primarily to invertebrates and plants.

7.2.2 Area 52

A focused ecological risk assessment was not performed for soil at Area 52. This area, which consists primarily of buildings and paved areas, was not screened because of its low value as habitat and because the area with the potentially contaminated media is not available to organisms. No surface water has been reported in the area. Chemicals detected at the site were limited to subsurface soil and groundwater. Because plants and animals are unlikely to be exposed directly to chemicals in subsurface soil, no risks are expected from subsurface soil contamination.

The ecological risk assessment for Area 52 groundwater was limited to the effects of groundwater as it discharges into the marine environment. As with Area 1, the ecological risk from groundwater at Area 52 is limited to the effects on the intertidal marine environment as the groundwater discharges into the Strait of Juan de Fuca. Chemicals detected in groundwater monitoring wells in Area 52 at concentrations exceeding marine water quality criteria are not expected to exceed these criteria at the point of discharge. The semivolatile COPCs in Area 52 groundwater (bis[2-ethylhexyl]phthalate and PAH compounds) will be subject to a high degree of retardation as adsorption to soil occurs. Vinyl chloride concentrations in wells near MW-4 are lower than those in MW-4 by a factor of three, demonstrating that dispersion is significant. Further dilution from tidal effects is expected for all COPCs in groundwater. Although free-phase petroleum hydrocarbons may be discharging into the intertidal zone, this has not been observed. No marine water quality criteria exist for petroleum hydrocarbons.

If chemical concentrations in the intertidal zone exceed ambient water quality criteria, certain sensitive intertidal species may be at risk. The biological survey found that normal communities of plants and animals are present in the Area 1 and Area 52 intertidal zone, with no apparent effects from groundwater discharge. Because this is a high-energy beach. the existing intertidal species are limited to marine algae, barnacles, sand fleas, etc. If the chemicals in groundwater were to affect the intertidal species, the reduced populations of intertidal species could cause other species that feed on the intertidal species to forage for their food at other locations. Bioaccumulation of Area 52 COPCs in animals at higher trophic levels is not expected, and thus no risks are expected to higher trophic level organisms.

7.2.3 Area 31

A focused ecological risk assessment was conducted at Area 31, according to both federal and Washington State guidance. Area 31 is principally terrestrial, with an area of seasonally saturated soils resulting from an area of low topography. Exposure modeling was used to evaluate potential ecological risks.

Exposure models use results of chemical analysis, chemical biotransfer factors, and exposure factors to provide conservative dose estimates for receptors. Estimated doses are compared with conservative toxicity reference values (TRVs) to evaluate risk. TRVs are available for some chemicals and media. They are not site-specific and may, therefore, lead to erroneous conclusions.

Methods

Data Evaluation. Data describing chemical concentrations in various media were evaluated for inclusion in the risk assessment. The environmental matrices include the biologically active portion of the soil profile (i.e., soil from the surface down to 60 cm, which is considered the maximum depth for root penetration, burrowing mammals, and the majority of soil-dwelling microflora and microfauna), the surface water, and the surface sediment (i.e., sediment from the surface down to 20 cm, which is the horizon of greatest biological activity). Groundwater was not considered in the ecological risk assessment because of the lack of an exposure route.

The average and RME concentrations of chemicals were estimated by using the arithmetic mean and the 95UCL of the arithmetic mean. When the 95UCL exceeded the maximum detected concentration, the maximum detected concentration was used to represent the RME concentration.

Chemical data were available from Phases I and II of the RI. All data were validated by the analytical laboratories and by an independent contractor.

COPC Selection. COPC selection in soil, surface water, and sediment was based on the frequency of detection; the nutritional essentiality of minerals and salts; a comparison with background concentrations; and a comparison with regulatory criteria, toxicological guidance values, or RBSCs.

Exposure Assessment. Area 31 is principally terrestrial, with seasonally saturated soils in areas. It is maintained void of trees and is predominantly a grass bushland. Species known to occur in the area include Douglas fir, western hemlock, western red cedar, grand fir, red alder, and big leaf maple. Common understory plants include salmonberry, elderberry, salal, Oregon grape, oceanspray, snowberry, and rose. In elevated microsites, dense patches of Scotch-broom predominate. Wildlife that may inhabit the area include cottontail rabbit and black-tailed deer. Domestic cats originating from the residences located east of the base are commonly observed at Area 31. No endangered, threatened, or unique species have been observed at Area 31. In addition, it is highly unlikely that species of concern listed for NAS Whidbey Island (i.e., bald eagle, osprey, and peregrine falcon) will use Area 31 for an ecologically significant percentage of time because of aircraft activity and the lack of suitable nesting habitat.

The following receptors and routes of exposure were selected for evaluation by exposure modeling:

- Root uptake from soil by any of a variety of endemic grasses

- Soil-dwelling invertebrate (earthworm)

  - Ingestion of soil
  - Ingestion of vegetation
  - Dermal sorption from contact with soil

- Herbivorous small mammal (Townsend's vole)

  - Ingestion of vegetation
  - Incidental ingestion of soil
  - Ingestion of surface water

- Herbivorous bird (California quail)

  - Ingestion of vegetation
  - Incidental ingestion of soil
  - Ingestion of soil as grit
  - Ingestion of surface water

- Insectivorous small mammal (masked shrew)

  - Ingestion of soil invertebrates (earthworms)
  - Incidental ingestion of soil

- Carnivorous mammal (long-tailed weasel)

  - Incidental ingestion of soil
  - Ingestion of Townsend's vole
  - Ingestion of surface water

- Carnivorous bird (northern harrier)

  - Ingestion of Townsend's vole

Chemical intake via each route of exposure was estimated using equations taken from the U.S. Fish and Wildlife Service and the EPA.

Results

Hazard quotients for terrestrial receptors at Area 31 are summarized in Table 11. Generally, an HQ exceeding 1.0 indicates some potential for adverse effects, but due to the conservative assumptions used in the modeling, actual risks are highly uncertain for HQs less than 10. Results of exposure modeling showed that four chemicals (lead, 2,3,7,8-tetrachlorodibenzo-p-dioxin [TCDD], N-nitrosodiphenylamine, and 2-butanone) had RME HQs exceeding 1.0 for at least one receptor. However, risks from two of these chemicals (N-nitrosodiphenylamine and 2-butanone) are considered highly unlikely because RME HQs are less than 10 and the models use highly conservative input parameters to assess risk. Ecological risks at Area 31 are therefore limited to the masked shrew and are attributable to lead and 2,3,7,8-TCDD in surface soil.

7.2.4 Ecological Risk Assessment Summary

Area 1 and Area 52

A focused ecological risk assessment was conducted for Area 1, and a qualitative ecological risk assessment was conducted for Area 52. In each case, results of chemical analyses were evaluated against site-specific RBSCs developed for ecological receptors. Ecological receptors for Area 1 were identified for soil and included a shrew for organic chemicals and earthworms and other soil invertebrates for inorganic chemicals. To assess ecological risk in other media at Area 1 (i.e., surface water and sediments), RBSCs were collected or derived from literature sources. In Area 52, soil is not expected to allow chemical exposure for ecological receptors; therefore, only groundwater was evaluated for its effects on the intertidal environment.

Potential ecological risks from groundwater at Area 1 and Area 52 would be limited to effects in the intertidal marine environment as the groundwater discharges into the Strait of Juan de Fuca. Chemical concentrations in inland monitoring wells at Areas 1 and 52 exceeded marine water quality criteria, but it is not known whether these exceedances occur at the point of discharge. Because the intertidal species present at Areas 1 and 52 are lower trophic level organisms such as marine algae, barnacles, and sand fleas, and because the COPCs in groundwater do not bioaccumulate, risks to higher trophic level organisms are expected to be minimal.

In Area 1 soil, copper, lead, and zinc showed some potential for adverse ecological impacts. However, the toxicity values used for these chemicals are based on plant and soil-dwelling invertebrate studies, and their relevance to higher trophic levels such as mammals and birds at this site is unknown. Also, because the majority of soil samples were from the landfill contents, the maximum detected concentrations in soils are not representative of actual exposures that ecological receptors might receive. Chemicals exceeding ecological RBSCs in Area 1 surface water include Aroclor 1254 and Aroclor 1260, cadmium, chromium, copper, bis(2-ethylhexyl)phthalate, mercury, 2-methylnaphthalene, vanadium, and zinc. Chemicals exceeding ecological RBSCs in Area 1 sediments include Aroclor 1254, copper, bis(2-ethylhexyl)phthalate, lead, nickel, and zinc. Although many chemicals in both surface water and sediments exceeded the RBSCs—and in some cases by relatively large magnitudes—the small size of the wetland and the impermanence of the surface water should limit ecological risk.

Table 11
Summary of Hazard Quotients to Terrestrial Receptors at Area 31

Chemical	Townsend's Vole		California Quail		Long-Tailed Weasel		Northern Harrier		Masked Shrew	
	Average	RME	Average	RME	Average	RME	Average	RME	Average	RME
2,3,7,8-TCDD	0.326	0.597	<0.1	<0.1	2.55	4.67	<0.1	<0.1	1130	2070
Lead	0.997	1.52	<0.1	<0.1	5.58	8.49	<0.1	<0.1	102	155
N-Nitrosodiphenylamine	0.251	0.435	NC	NC	<0.1	0.119	NC	NC	4.18	7.23
2-Butanone	0.736	1.7	NC	NC	<0.1	<0.1	NC	NC	1.28	2.95

Notes:
NC Not calculated
RME Reasonable maximum exposure
TCDD Tetrachlorodibenzo-p-dioxin

Area 31

Although exposure modeling indicated potential adverse impacts to the masked shrew attributable to 2,3,7,8-TCDD and lead, potential risks to the shrew from the 2,3,7,8-TCDD are considered highly uncertain due to the limited current knowledge of its toxicity. No risks were identified to birds or carnivorous animals.

7.3 SUMMARY OF SITE RISKS

At Areas 1 and 52, no potential for significant human health risks were found and no human health COCs were defined. Some potential ecological risk was found in the marine water next to and originating from the sites. At Area 31, there was limited human health risk from contaminated soils and a human health risk in the groundwater. There was limited ecological risk at Area 31.

Actual or threatened releases from Areas 1, 52, and 31, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to human health and the environment.

8.0 REMEDIAL ACTION OBJECTIVES

This section explains the basis for remedial action at OU 5, identifies the media for which action is needed, and describes the objectives that the remedial action is intended to achieve. Based on these remedial action objectives (RAOs), specific cleanup levels are defined for specific chemicals in the media of concern.

8.1 AREA 1

8.1.1 Need for Remedial Action

The human health risk assessment evaluated the exposure of future recreational visitors to chemicals in soil, surface water, and sediments and exposure of industrial workers to chemicals in soil at Area 1. Exposure to chemicals in groundwater was not evaluated because groundwater is not a potential source of drinking water. As discussed in

Section 7.1.5, the estimated human health risks were below the screening levels for all of the exposure scenarios at Area 1. Because the human health risk assessment determined that there are no current or potential future human health risks at Area 1, no actions are needed to protect human health.

The following subsections discuss the need for remedial action as determined by the results of the ecological risk assessment and consideration of ARARs for soil, surface water, sediments, and groundwater at Area 1. Specific RAOs are presented for each medium.

Soil

The ecological risk assessment indicated some potential for adverse impacts to birds and mammals attributable to three COCs (copper, lead, and zinc) in Area 1 soils. However, there was a high degree of uncertainty associated with the potential ecological risks. One COC (gasoline-range petroleum hydrocarbons), whose concentration in soil exceeds state cleanup levels, has been identified in subsurface soils.

Remedial action objectives were not developed for Area 1 soils because the soils did not pose current or potential future human health risks exceeding the CERCLA risk range, and no clear ecological risk was present.

Surface Water (Fresh Water)

The ecological risk assessment indicated no significant potential for adverse impacts to aquatic animals attributable to Area 1 surface water. Several COCs (lead, mercury, zinc, Aroclor 1254, Aroclor 1260, and diesel-range petroleum hydrocarbons) have been identified whose concentrations in surface water exceed regulatory criteria. However, no COCs exceed regulatory criteria in surface water from the drainage downgradient of the wetland in the middle of the Area 1 landfill. As discussed in Section 6, the source of these chemicals appears to be upgradient stormwater drainage, and the wetland functions to remove these chemicals from surface water before its discharge to the marine environment.

Because no risks are associated with these chemicals and the wetland naturally removes these chemicals from surface water, no RAOs have been developed for Area 1 surface water.

Freshwater Sediments

The ecological risk assessment indicated no significant potential for adverse impacts to birds and mammals attributable to Area 1 sediments. COCs (lead and Aroclor 1254) have been identified whose concentrations in sediments exceed state soil cleanup levels. Because no freshwater sediment cleanup levels were available, the MTCA Method B soil cleanup levels were used in the RI for comparison purposes only.

Remedial action objectives were not developed for Area 1 sediments because the sediments did not pose current or potential future human health risks exceeding the CERCLA risk range, and no clear ecological risk was present.

Groundwater

Drinking water is not considered the highest beneficial use for groundwater at Area 1 under Washington State regulations. Therefore, no human health or ecological risks associated with Area 1 groundwater were defined in the human health and ecological risk assessments because groundwater was not considered as a potential source of exposure.

In the absence of future drinking water potential, MTCA allows groundwater cleanup levels that are based on protecting beneficial uses of adjacent surface water. MTCA requires that groundwater entering surface waters not exceed surface water cleanup levels at the point of entry or at any downstream location where it is reasonable to believe that hazardous substances may accumulate (WAC 173-340-720[c][iii]). According to this approach, four COCs (cyanide, zinc, 1,1-dichloroethene, and bis[2-ethylhexyl]phthalate) have been identified whose concentrations in groundwater exceed marine ambient water quality criteria or other regulatory criteria for surface water. Dilution of groundwater occurs prior to discharge to the Strait of Juan de Fuca, and these exceedances in monitoring wells may not indicate actual exceedances at the point of entry into the marine environment.

Cyanide is the chemical of greatest concern in Area 1 groundwater, due to the magnitude of its exceedance of marine water quality standards and the potential for ecological risks in the intertidal zone that this large exceedance implies. However, cyanide concentrations were not measured in the intertidal wells because of funding and schedule concerns, so the actual concentrations of cyanide at the point where groundwater discharges to the intertidal zone are not known. Any effects of cyanide would be limited to organisms in the intertidal zone, such as barnacles and sand fleas. A biological survey of the intertidal zone revealed normal communities of plants and animals, with no apparent ill effects from groundwater discharge. Cyanide does not bioaccumulate in animals and is not expected to pose risks to birds or marine animals. Based on this evidence, the Navy is assuming that cyanide in groundwater does not present significant ecological risk. Further sampling at the point where groundwater discharges to the intertidal zone is needed to confirm this assumption.

To address potential adverse impacts to marine life associated with these chemicals in groundwater, the following RAO has been developed for Area 1 groundwater:

- Confirm protection of ecological receptors in the marine environment by determining compliance with the water quality standards for marine surface waters at the point of groundwater discharge

8.1.2 Remedial Goals

The RAO for groundwater defined in the previous section includes evaluating potential ecological risks and complying with chemical-specific ARARs. Chemical-specific ARARs for Area 1 groundwater that correspond with the RAO are presented in Table 12. The most stringent of these criteria will be used to evaluate groundwater quality at the point of discharge and assess the protection of ecological receptors in the marine environment.

8.2 AREA 52

8.2.1 Need for Remedial Action

The human health risk assessment evaluated the exposure of future industrial workers to chemicals in subsurface soil at Area 52. The current industrial worker exposure was not evaluated because no COCs were found in surface soil at Area 52. Exposure to groundwater was not evaluated because groundwater is not a potential source of drinking water. As discussed in Section 7.1.5, the estimated human health risks were below the CERCLA target levels for all of the exposure scenarios at Area 52. Thus, the human health risk assessment did not demonstrate a need to take remedial action at Area 52 to protect human health. The following subsections discuss the need for remedial action as determined by the results of the ecological risk assessment. Specific RAOs are presented for each medium.

Table 12
Chemical-Specific ARARs for Area 1 Groundwater

Chemical	Maximum Detected Concentration (μg/L)	Background Concentration (μg/L)	Chemical-Specific ARARs (μg/L)			
			Washington Marine WQS[a]	Federal Marine WQC[a]	MTCA Method B (Surface Water)[b]	Selected Cleanup Level
Cyanide	152	0	1[c]	1[c]	51,900	1
Zinc (dissolved)	146	56	76.6[d]	86[d]	16,500	76.6
1,1-Dichloroethene	5	0	NA	224,000[c,e]	1.93	1.93
bis(2-Ethylhexyl) phthalate	90	0	NA	NA	3.56	3.56

[a]Based on protection of aquatic life.
[b]MTCA Method B groundwater cleanup level is based on protection of human health from human consumption of organisms from adjacent surface water.
[c]Based on acute exposure.
[d]Based on chronic exposure.
[e]To-be-considered (TBC) value based on lowest-observed-effects level.

Notes:
MTCA Model Toxics Control Act
NA No available value
WQS Water quality standard

Soil

The ecological risk assessment concluded that no ecological risks were expected at Area 52. One COC (diesel-range petroleum hydrocarbons) has been identified whose concentrations in subsurface soil exceed state cleanup levels.

Remedial action objectives were not developed to address the exceedances of a chemical-specific ARAR because soils at Area 52 did not pose current or potential future human health risks exceeding the CERCLA risk range, and no clear ecological risk was present.

Groundwater

Drinking water is not the highest beneficial use for groundwater at Area 52 under Washington State regulations. Therefore, no human health or ecological risks associated with Area 52 groundwater were defined in the human health and ecological risk assessments because groundwater was not considered as a potential source of exposure. However, floating petroleum product is present and COCs have been identified (vinyl chloride, bis[2-ethylhexyl]phthalate, carcinogenic PAHs [cPAHs], and petroleum hydrocarbons) whose concentrations in Area 52 groundwater exceed marine ambient water quality criteria or other regulatory criteria. The thickness of the floating petroleum product plume is diminishing over time, and the plume appears to be breaking up. While petroleum product was not detected in the intertidal sandpoint monitoring wells, dissolved petroleum constituents were found at concentrations below regulatory levels. This indicates that petroleum constituents are migrating toward the marine surface water, but at concentrations below regulatory levels.

Dilution of chemicals in groundwater occurs prior to discharge to the Strait of Juan de Fuca, and exceedances of regulatory criteria in inland monitoring wells may not indicate actual exceedances at the point of entry into the marine environment. To address potential adverse impacts to marine life associated with these chemicals in groundwater, the following RAOs have been developed for Area 52 groundwater:

- Prevent the migration of floating petroleum product from groundwater to marine surface water

- Confirm protection of ecological receptors in the marine environment by determining compliance with the water quality standards for marine surface waters at the point of groundwater discharge

8.2.2 Remedial Goals

The RAOs for groundwater defined in the previous section include reducing potential ecological risks and complying with chemical-specific ARARs. Chemical-specific ARARs for Area 52 groundwater that correspond with the RAO are presented in Table 13. These criteria will be used to evaluate groundwater quality at the point of discharge, evaluate the effectiveness of the selected remedy, and assess the protection of ecological receptors in the marine environment.

Table 13
Chemical-Specific ARARs for Area 52 Groundwater

Chemical	Maximum Detected Concentration (µg/L)	Chemical-Specific ARARs (µg/L)		
		Federal Water Quality Standards for Marine Water (40 CFR 131)	Washington State Water Quality Standards for Marine Water (WAC 173-201A)	MTCA Method B Cleanup Level[a]
Vinyl chloride	63	NA	NA	2.92
Benzo(a)anthracene	0.04	NA	NA	0.0296
Benzo(a)pyrene	0.07	NA	NA	0.0296
Benzo(b)fluoranthene	0.05	NA	NA	0.0296
Chrysene	0.05	NA	NA	0.0296
Indeno(1,2,3-cd)pyrene	0.04	NA	NA	0.0296
TPH	36,000	NA	NA	1,000[b]

[a]MTCA Method B groundwater cleanup level is based on protection of adjacent surface water.
[b]MTCA Method A groundwater cleanup level.

Notes:
MTCA Model Toxics Control Act
NA No criteria promulgated
TPH Total petroleum hydrocarbons

8.3 AREA 31

8.3.1 Need for Remedial Action

The human health risk assessment evaluated the exposure of current on-site workers and future residents to chemicals in soil, ditch sediments, and groundwater at Area 31. Groundwater was evaluated as a potential future source of drinking water because the shallow aquifer at Area 31 is a potential source of drinking water under Washington State regulations. As discussed in Section 7.1.5, the estimated human health risks were below the CERCLA target levels for all of the exposure scenarios at Area 31, with the exception of potential noncancer risks due to manganese in groundwater under the future residential scenario. Also, the risk assessment assumed that groundwater from a well containing floating petroleum product would not be used as a source of drinking water, because this would present a clear risk to human health. Thus, although numeric risk estimates were not made based on samples from the monitoring well that contained floating petroleum product, the petroleum would present a risk if a drinking water well were installed at Area 31. Currently, groundwater at Area 31 is not used for drinking water. Thus, remedial actions designed to prevent potential human health risks from manganese and petroleum in groundwater were considered. The following subsections discuss the need for remedial action as determined by the results of the human health and ecological risk assessments and consideration of ARARs for soil, ditch sediments, and groundwater at Area 31. Specific RAOs are presented for each medium.

Soil, Ditch Sediment, and Ash

The baseline human health risk assessment estimated that current and future risks due to chemicals in soil in Area 31 were within the acceptable CERCLA risk range, with the exception of lead. Lead concentrations in an isolated area of ash and adjacent ditch surface sediment could pose a potential human health risk.

The ecological risk assessment evaluated ecological risks due to chemicals in surface soil. Subsurface soil (below 2 feet) was not evaluated because organisms at Area 31 are not likely to be exposed to that medium. Ash was not evaluated because it was assumed to be scheduled for a remedial action and therefore would not pose a risk to ecological receptors. The ecological risk assessment indicated the potential for adverse ecological effects because of COCs in the upper 2 feet of Area 31 surface soil. Lead and dioxin were identified in surface soil as COCs that may cause potential adverse effects to the masked shrew. No significant ecological risks were identified for other mammals, raptors (e.g., hawks and owls), or herbivorous birds. The ecological risk assessment concluded that potential risks to the shrew are highly uncertain; therefore, RAOs based on protecting the masked shrew were not developed.

Exceedances of chemical-specific ARARs (MTCA cleanup levels) were identified for beryllium, lead, Aroclor 1260, dioxins, indeno(1,2,3-cd)pyrene, and petroleum hydrocarbons in soil at Area 31. Lead also exceeded the MTCA cleanup level in one ash sample and in one ditch sediment sample. Because the ditch sediments are vegetated and are relatively immobile, no remedial action objectives were developed to address the one lead exceedance in sediments. Beryllium is widely distributed in surface and subsurface soil at Area 31. The maximum concentration of 0.88 mg/kg is only 1.7

times the background concentration of 0.52 mg/kg. Because the concentration is not significantly above background, beryllium is not considered a target chemical for remediation.

Remedial action objectives were not developed to address these exceedances of chemical-specific ARARs because soils at Area 31 did not pose current or potential future human health risks exceeding the CERCLA risk range, and potential ecological risks were uncertain and limited to the masked shrew. However, petroleum hydrocarbons found in subsurface soils near the oil/water separator are a source of groundwater contamination. To address this impact to groundwater quality, the following RAO was developed for Area 31 soil:

- Reduce the sources of petroleum hydrocarbons in subsurface soils that may cause groundwater contamination in excess of state cleanup levels for petroleum hydrocarbons

To address potential human health risks due to lead in ash, the following RAO was developed:

- Prevent human exposure to lead in ash

Groundwater

The primary concern with Area 31 groundwater is the presence of floating petroleum product on the groundwater near the oil/water separator, which would pose an unacceptable human health risk if a drinking water well were installed in the area of the floating petroleum product and immediately downgradient (within about 50 feet). The floating petroleum product is acting as an ongoing source of dissolved COCs that could potentially spread in groundwater.

The baseline risk assessment estimated that current human health risks were within the acceptable CERCLA risk range for Area 31 groundwater. Under the future residential scenario, which assumes the use of groundwater as a source of drinking water, unacceptable human health risks would exist in the area of the floating petroleum product. Manganese in groundwater would pose an unacceptable noncancer risk. Groundwater was not considered a medium of potential concern for ecological risk.

Exceedances of chemical-specific ARARs were identified for several chemicals detected in groundwater at Area 31, as shown in Tables 4 and 5. These COCs include petroleum hydrocarbons, dioxins and furans, VOCs, SVOCs, inorganics, and PCBs (Aroclor 1260).

Concentrations of manganese in groundwater may be elevated as a result of reducing conditions associated with microbial degradation of petroleum. Remediation of the petroleum constituents may shift the nature of the groundwater to oxidizing conditions, causing the manganese to precipitate out of the groundwater. The remainder of the COCs are associated with floating petroleum product near the oil/water separator or the UST.

To address the possible future human health risk and exceedances of ARARs associated with these chemicals, and to prevent the potential spreading of contamination in groundwater, the following RAOs were developed for Area 31 groundwater:

- Prevent the migration of floating petroleum product and dissolved COCs that are present above ARARs in groundwater
- Prevent human exposure under the future residential scenario to the COCs in groundwater that are present at concentrations above state and federal cleanup levels

8.3.2 Remedial Goals

The RAOs for soil and groundwater defined in the previous section include reducing potential future human health risks and complying with chemical-specific ARARs.

For Area 31 soil, numeric chemical-specific cleanup levels were not developed. The RAO for soil is based on reducing or eliminating impacts to groundwater quality. The effectiveness of the remedy in achieving the soil RAO will therefore be evaluated based on the results of groundwater monitoring.

For Area 31 groundwater, chemical-specific cleanup levels that correspond with the RAOs are presented in Table 14. The effectiveness of the remedy in achieving the groundwater RAOs will be evaluated primarily with regard to preventing the spread of COCs at concentrations above these cleanup levels. Exceedances of the groundwater cleanup levels in some wells may persist on site for some time and would be addressed through institutional controls to prevent groundwater use.

Table 14
Chemical-Specific ARARs for Area 31 Groundwater

Chemical	Maximum Concentration (μg/L)	Background Concentration (μg/L)	Chemical-Specific ARARs (μg/L)			
			Federal MCL	State MCL	MTCA Method B for Groundwater	Selected Cleanup Level
Beryllium	0.29	NC	4		0.0203	0.0203
Lead	198	9.7	15	50	5[a]	9.7
Manganese	3,780	125			80	125
Mercury	3.6	0.3	2	2	4.8	2.0
Aroclor 1260	0.70	0	0.5		0.011	1[b]
Benzene	380	0	5	5	5	5
Naphthalene	900	0			320	320
Pentachlorophenol	7	0	1		1	1
Styrene	2	0	100		1.46	1.46
Toluene	3,200	0	1,000		1,600	1,000
Vinyl chloride	4	0	2	2	0.023	0.1[b]
2,3,7,8-TCDD (TEC)	5.3×10^{-3}	0	30×10^{-6}		0.58×10^{-6}	0.58×10^{-6}
TPH	230,000	0			1,000[a]	1,000

[a]MTCA Method A groundwater cleanup level.
[b]Based on practical quantitation limit obtained from "Guidance on Sampling and Data Analysis Methods," January 1995 (Ecology Publication 94-49).

Notes:
MCL Maximum contaminant level
MTCA Model Toxics Control Act
NC Not calculated because this analyte was not detected in background samples
TCDD Tetrachlorodibenzo-p-dioxin
TEC Toxicity equivalent concentration (individual dioxins/furans concentrations were converted to equivalent 2,3,7,8-TCDD concentrations using EPA's toxicity equivalency factors)
TPH Total petroleum hydrocarbons

The ash piles at Area 31 are scheduled for removal; hence, no numeric cleanup levels are developed for the ash.

9.0 DESCRIPTION OF ALTERNATIVES

The feasibility studies assessed a range of alternatives for remediation of OU 5. Based on the results of the risk assessment and the RAOs discussed in Section 8, the remedial alternatives were developed to address potential risks from each area at OU 5.

The following sections provide a brief description of each alternative evaluated for each area, including the estimated capital cost and operating and maintenance (O&M) costs for implementation.

9.1 AREA 1

Three remedial alternatives have been considered for Area 1.

9.1.1 Alternative 1—No Action

The no-action alternative was included in the range of alternatives evaluated in the feasibility study, as required by the NCP. Alternative 1 includes no specific response actions to reduce contaminants at the site, control their migration, or prevent exposures. The no-action alternative serves as a baseline from which to judge the performance and cost of other action-oriented alternatives.

Costs for Alternative 1 are the following:

Capital cost:	$0
Present value O&M costs:	$0
Total present worth:	$0

9.1.2 Alternative 2—Limited Action—Institutional Controls and Monitoring

Alternative 2 would use institutional controls to limit human exposure to COCs present in surface and subsurface soils and groundwater. The potential for ecological risks in the marine environment would be further assessed through a groundwater monitoring program. This alternative includes three components: deed restrictions, environmental monitoring, and periodic reviews of environmental data. These components are discussed in the following paragraphs.

To prevent residential development or the installation of drinking water wells, land-use restrictions will be entered into the installation restoration site database that is part of the NAS Whidbey Island planning and management model. These restrictions would include special requirements for any other construction activity that may disturb contaminated soil, including health and safety plans, environmental protection plans, and waste management plans. In the event of property transfer, restrictive covenants on the property would be recorded with the Island County register of deeds. The covenants would be binding on the owner's successors and assignees, would place limiting conditions on property conveyance, would prohibit well construction except for monitoring purposes, and would restrict land use and construction activity that would disturb the landfill. These restrictions would apply to the landfill plus an appropriate buffer zone. Covenants would also require notice to environmental regulatory agencies (e.g., the EPA, Ecology, or their designees) of any intent to transfer interest, modify its land use, or implement construction activity; agency approvals would be required for such actions.

Continued use of existing security measures would control physical access to Area 1 by the general public.

An environmental monitoring program would include groundwater sampling and biological surveys of the beach. In the 1st year, the two inland monitoring wells (MW-18 and MW-103) will be resampled one time for cyanide, and up to six intertidal groundwater samples would be collected from seeps along the shoreline. The intertidal groundwater seep samples would be analyzed for total and dissolved inorganics, cyanide, VOCs, and SVOCs to determine compliance with surface water cleanup levels. If the results of the intertidal groundwater sampling indicate compliance with surface water cleanup levels, the sampling would be terminated.

If the results of the 1st year intertidal groundwater sampling indicate that surface water cleanup levels are not met in the intertidal groundwater seep samples, the following monitoring program would be instituted: A biological survey of the intertidal zone would be conducted in the 2nd year. Up to six intertidal groundwater samples would be collected annually from seeps along the shoreline, beginning in the 2nd year. The intertidal seep samples would be analyzed for total and dissolved inorganics, cyanide, VOCs, and SVOCs to determine compliance with surface water cleanup levels in the first year. After the 1st year of monitoring, the Navy and the EPA would consider limiting the chemical analyses in subsequent years to those chemicals detected during the 1st year. If the results of the intertidal groundwater seep sampling indicate compliance with surface water cleanup levels for 2 consecutive years, the annual sampling would be terminated. If compliance with surface water cleanup levels has not been attained for 2 consecutive years by the 5th year, a second biological survey of the intertidal zone would be conducted.

Included in the monitoring program would be visual inspections of the physical condition of the landfill bluff conducted annually for the first 5 years, and the results documented.

Because this alternative would result in some remaining exceedances of cleanup levels in soils and potentially in groundwater, a periodic review of the environmental data would be required no less frequently than every 5 years. The environmental data will be used by the EPA and Navy to jointly assess the protection of ecological receptors in the marine environment.

Estimated costs for Alternative 2 are the following, assuming 5 years of operation and a 5 percent discount factor:

Capital cost:	$25,000
Present value O&M costs:	$109,000
Total present worth:	$134,000

9.1.3 Alternative 3—MFS Cap and Installation of Seawall

Alternative 3 consists of placing a minimum functional standards (MFS) cap over the surface of the Area 1 landfill. An MFS cap is the standard cap required for the closure of solid waste landfills. Alternative 3 also includes construction of an approximately 1,100-foot-long seawall along the shoreline of the Area 1 landfill to prevent erosion.

The western edge of the landfill along the shoreline would be regraded as necessary for the construction of the seawall. Landfill material removed during the regrading would be consolidated elsewhere within the landfill boundaries. A seawall would be constructed from oversized riprap, extending approximately 1,100 feet along the shoreline. The precise length and configuration of the seawall would be determined, after surveying, in the remedial design. The seawall would reduce the potential for landfill erosion into the Strait of Juan de Fuca during storm events and would protect the landfill cap.

The MFS cap would be placed over the identified extent of the landfill (approximately 330,000 square feet). The proposed design of the MFS cap, intended to comply with the requirements of WAC 173-304, is presented below:

1. The landfill surface would be extensively regraded to facilitate drainage. Because of design requirements, the wetlands would necessarily be filled and covered by the cap. An average 6-inch-thick aggregate leveling base would be placed on top of the regraded landfill surface.

2. A geosynthetic clay liner would be installed on the top surface of the aggregate leveling base.

3. The third layer from the top would be an impermeable flexible membrane layer composed of a 60-mil high-density polyethylene sheet.

4. The second layer from the top would be a synthetic drainage layer that is a net-like product of two overlapping polyethylene strands covered with a geotextile fabric on both sides.

5. The top layer would consist of a 2-foot-thick soil layer conducive to sustaining vegetative growth. The top of the vegetative soil layer would be fertilized and seeded with native vegetation.

6. The existing 24-inch storm drain outfall that currently feeds the wetland in the middle of the Area 1 landfill would be re-routed directly to the Strait of Juan de Fuca.

The MFS-type cap would eliminate the potential risk associated with COCs in soils and sediments by preventing the exposure of human and ecological receptors to existing soils and sediments. By preventing percolation of precipitation through vadose-zone soils, the potential for transport of soil contaminants to groundwater may be reduced. However, it is not certain that this percolation is causing significant groundwater contamination. Further, under this alternative, the wetlands at Area 1 would be destroyed, and surface water runoff from the storm drain would discharge directly to the marine environment.

Groundwater monitoring, deed restrictions, and periodic reviews would be implemented as described for Alternative 2.

Estimated costs for Alternative 3 are the following, assuming 5 years of operation and a 5 percent discount factor:

Capital cost:	$2,060,000
Present value O&M costs:	$131,000
Total present worth:	$2,191,000

9.2 AREA 52

Two remedial alternatives have been considered for Area 52.

9.2.1 Alternative 1—No Action

The no-action alternative was included in the range of alternatives evaluated in the feasibility study, as required by the NCP. Alternative 1 includes no specific response actions to reduce contaminants at the site, control their migration, or prevent exposures. The no-action alternative serves as a baseline from which to judge the performance and cost of other action-oriented alternatives.

Costs for Alternative 1 are the following:

Capital cost:	$0
Present value O&M costs:	$0
Total present worth:	$0

9.2.2 Alternative 2—Oil Skimming

Alternative 2 would use institutional controls to limit human exposure to petroleum hydrocarbons present in subsurface soils and groundwater. In addition, to prevent migration of petroleum to adjacent surface water, floating petroleum product would be removed from the water table surface by skimming devices. The marine environment would be monitored for ecological effects, and groundwater seeps would be monitored for petroleum hydrocarbons and other COCs. The thickness of the floating petroleum product plume would be monitored to evaluate the effectiveness of the skimming.

The removal of floating petroleum product at Area 52 can be accomplished via two general approaches: (1) using extraction wells to pump water and floating petroleum product, creating cones of depression that draw floating petroleum product toward the extraction wells, or (2) using skimming devices to remove floating petroleum product while extracting little or no groundwater. The results of the treatability study at Area 52 have indicated that pumping rates in excess of 25 to 50 gallons per minute per extraction well would be required to create sufficient cones of depression to draw floating petroleum product toward the extraction wells. Furthermore, because the plume has migrated, additional extraction wells would be required. Saltwater intrusion would likely result from the high pumping rates. Treatment of the extracted, high-salinity water could not be accomplished in a publicly-owned treatment works or the Navy treatment works. Discharge of this extracted water directly to marine waters would be required and may be difficult to implement on a regulatory basis. Therefore, the second approach (skimming devices) is considered the most technically feasible technology type.

The results of the treatability study and ongoing monitoring at Area 52 have indicated that the floating petroleum product is continually migrating, is apparently heterogeneous in its extent (i.e., isocontour lines are difficult to draw), and may vary in extent from wet season to dry season. Therefore, the removal system design should be regarded as a conceptual design that may be modified significantly in the remedial design based on further monitoring of the floating petroleum product. The proposed configuration of the floating petroleum product removal system is described below.

The existing monitoring wells that are screened across the water table surface would be used as collection points for removal of floating petroleum product. Up to five additional monitoring/collection wells would be installed and screened across the water table surface. The locations of the additional wells would be chosen to provide additional coverage near the Jet Engine Test Cell and downgradient, where the plume is expected to migrate. The exact number and locations of the wells would be determined in the remedial design. The wells would be designed to operate with skimming devices that collect floating petroleum product and prevent the collection of groundwater. Collected petroleum would be emptied into approved containers and sent off site for recycling and/or disposal. The oil skimming wells would be operated until it becomes impractical to recover significant amounts of oil. It is estimated that the skimming would be completed in less than 5 years.

Because this configuration relies on the natural movement of the floating petroleum product plume toward the collection wells, the remediation is expected to take several years. This timeframe would also allow natural recovery of subsurface soils behind the floating petroleum product plume.

The 6-inch-diameter drywell at Area 52 would be excavated to prevent possible unauthorized disposal in the future. The excavation would be backfilled with borrow soils. No confirmation sampling would be conducted for the drywell removal. To prevent residential development or the installation of drinking water wells, land-use restrictions will be entered into the installation restoration site database that is part of the NAS Whidbey Island planning and management model. These restrictions would include special requirements for any other construction activity that may disturb contaminated soil, including health and safety plans, environmental protection plans, and waste management plans. In the event of property transfer, restrictive covenants on the property would be recorded with the Island County register of deeds. The covenants would be binding on the owner's successors and assignees, would place limiting conditions on property conveyance, would prohibit well construction except for monitoring purposes, and would restrict land use and construction activity that would disturb the site. These restrictions would apply to the site plus an appropriate buffer zone. Restrictions on construction activities that may disturb subsurface soils may be required only for a limited period (e.g., 10 to 30 years) until natural recovery reduces concentrations of petroleum hydrocarbons below remedial goals. Covenants would also require notice to environmental regulatory agencies (e.g., the EPA, Ecology, or their designees) of any intent to transfer interest, modify its land use, or implement construction activity; and agency approvals would be required for such actions.

A quarterly monitoring program would be implemented to monitor the thickness of the floating petroleum product to determine the movement. The measurements of floating petroleum product would be timed to coincide with high and low seasonal water levels.

An environmental monitoring program would include intertidal groundwater seep sampling and biological surveys of the beach. Intertidal groundwater seep samples would be collected biannually, in years 1, 3, and 5 following ROD signature. In each sampling event, up to six intertidal groundwater samples would be collected from seeps along the shoreline and analyzed for VOCs, SVOCs, and TPH to determine compliance with surface water cleanup levels. After the 1st year of monitoring, the Navy and the EPA would consider limiting chemical analyses in subsequent years to those chemicals detected during the 1st year. The surface water cleanup levels are shown in Table 13. The point of compliance for attaining these cleanup levels is in the seeps along the shoreline. Biological surveys of the intertidal zone would be conducted in years 2 and 5 following ROD signature.

Because this alternative would result in some remaining exceedances of cleanup levels in soils, a periodic review of the environmental data would be required no less frequently than every 5 years. The environmental data will be used to evaluate the effectiveness of the remedy and assess the protection of ecological receptors in the marine environment.

Estimated costs for Alternative 2 are the following, assuming 5 years of operation and a 5 percent discount factor:

Capital costs:	$54,000
Present value O&M costs:	$159,000
Total present worth:	$213,000

9.3 AREA 31

Four remedial alternatives have been considered for Area 31.

9.3.1 Alternative 1—No Action

The no-action alternative was included in the range of alternatives evaluated in the feasibility study, as required by the NCP. Alternative 1 includes no specific response actions to reduce contaminants at the site, control their migration, or prevent exposures. The no-action alternative serves as a baseline from which to judge the performance and cost of other action-oriented alternatives.

Costs for Alternative 1 are the following:

Capital cost:	$0
Present value O&M costs:	$0
Total present worth:	$0

9.3.2 Alternative 2—Oil Skimming

Alternative 2 would use institutional controls to limit exposure to COCs in surface and subsurface soils and to prevent exposure to COCs in groundwater. The oil/water separator tank would be excavated and removed for off-site disposal. In addition, to prevent further migration of petroleum and related chemicals in groundwater, oil skimming wells would be installed around the oil/water separator to remove floating petroleum product.

To prevent residential development or the installation of drinking water wells, land-use restrictions will be entered into the installation restoration site database that is part of the NAS Whidbey Island planning and management model. These restrictions would include special requirements for any other construction activity that may disturb contaminated soil, including health and safety plans, environmental protection plans, and waste management plans. Installation of drinking water wells would be prohibited over the area where site-related contaminant levels in groundwater exceed cleanup levels. In the event of property transfer, restrictive covenants on the property would be recorded with the Island County register of deeds. The covenants would be binding on the owner's successors and assignees, would place limiting conditions on property conveyance, would prohibit well construction except for monitoring purposes, and would restrict land use and construction activity that would disturb subsurface soil. Covenants would also require notice to environmental regulatory agencies (e.g., the EPA, Ecology, or their designees) of any intent to transfer interest, modify its land use, or implement construction activity; and agency approvals would be required for such actions.

The oil skimming wells would be installed within the zone where floating petroleum product is present on the groundwater. Active pumping of groundwater would not be used, in order to avoid (1) smearing the petroleum downward into saturated zone soils, where it would become unrecoverable, and (2) the need for groundwater treatment (which was shown in the feasibility study report to be expensive for the protection gained). The wells would be designed to operate with skimming devices that collect oil (liquid-phase hydrocarbons) and prevent the collection of groundwater. The collected oil would be containerized for transport to an off-site recycling or treatment facility. The containerized material would be sampled and analyzed to determine appropriate treatment and recycling requirements. If recycling is not possible, then the collected oil would be treated and/or disposed of in accordance with state and federal regulations. The oil skimming wells would be operated until it becomes impractical to recover significant amounts of oil. It is estimated that the skimming would be completed in less than 5 years.

Petroleum-contaminated soil excavated during the removal of the oil/water separator would be backfilled into the excavation. Confirmation samples would not be collected from the excavated soil or the limits of excavation.

The ash piles at Area 31 would be removed by the Navy and disposed of in accordance with state and federal regulations. No confirmation sampling would be conducted for the ash pile removal.

No further remedial action would be conducted at the burn pad or the location of the former UST. The land-use restrictions discussed above would include these areas.

With the removal of petroleum hydrocarbons by the oil skimming wells, concentrations of petroleum hydrocarbons are expected to eventually decline in the aquifer as the result of natural biodegradation processes.

A groundwater monitoring program would be conducted to verify that petroleum and other COCs in groundwater are not migrating and that contaminants have naturally attenuated before removing or redefining institutional control boundaries. Samples would be collected annually from up to four monitoring wells, using low-flow sampling techniques. In the first 4 years of groundwater monitoring, samples would be collected near the oil/water separator and analyzed for TPH. If after a suitable period of time the monitoring results indicate that TPH in groundwater is not migrating, the yearly monitoring would be terminated. In the 5th year, groundwater samples would be collected throughout the groundwater plume and analyzed for TPH, VOCs, and manganese.

No active remediation of COCs dissolved in groundwater is included in this alternative; however, natural attenuation is expected to occur. Because this alternative would result in some remaining exceedances of cleanup levels in soil and groundwater, long-term monitoring of groundwater would be required no less frequently than every 5 years.

Estimated costs for Alternative 2 are the following, assuming 5 years of operation and a 5 percent discount factor:

Capital cost:	$143,000
Present value O&M costs:	$114,000
Total present worth:	$257,000

9.3.3 Alternative 3—Oil Skimming and Bioventing

Alternative 3 would address RAOs for the site by means of the same actions and rationale described for Alternative 2, except that, in addition, bioventing treatment technology would further reduce potential petroleum sources in the vicinity of the oil/water separator. These actions would remove or treat a large portion of the source of groundwater contamination.

The bioventing process would treat petroleum-contaminated soil in the vadose zone surrounding the oil/water separator. Bioventing is an in situ treatment technology that involves the use of a vacuum pump or blower to introduce air into the vadose zone through wells or trenches to promote or enhance the natural biodegradation processes of native aerobic bacteria in the soil. Bacteria that degrade petroleum hydrocarbons are generally present in the soil at older petroleum spill sites; however, the degradation rates are usually slow because the bacteria have a limited oxygen supply. When air is introduced into such an environment, the oxygen-limited conditions are alleviated, and the biodegradation rates are typically enhanced substantially. The scientific literature includes descriptions of various sites where bioventing has successfully degraded petroleum hydrocarbons contaminating the vadose zone, even without external applications to enhance soil moisture, nutrient, and temperature conditions.

Bioventing uses similar equipment as soil vapor extraction, but the operation of the equipment differs. In soil vapor extraction, a vacuum pump withdraws soil vapor at relatively high rates to promote volatilization and removal of volatile compounds from the soil. In bioventing, air is introduced into the soil zone at much lower rates, sufficient only to provide the oxygen needed for biodegradation. Furthermore, in bioventing, the air may be introduced by a blower with injection wells. The air supply system for a bioventing process is designed to minimize or eliminate the need to control emissions. Bioventing was selected for this alternative rather than soil vapor extraction because bioventing provides better treatment of the heavier petroleum compounds that are not volatile and eliminates the expense of air emissions controls.

The bioventing process would operate in conjunction with the oil skimming system described for Alternative 2, after excavation and removal of the oil/water separator. Alternative 3 would include all the actions described for Alternative 2; in summary, Alternative 3 includes the following actions:

- Oil skimming wells and off-site treatment or recycling of skimmed product
- Removal and off-site disposal of oil/water separator
- Backfilling of any excavated soil

- Bioventing of vadose zone soils near the oil/water separator
- Removal of ash piles from the site
- Institutional controls as described for Alternative 2
- Groundwater monitoring as described for Alternative 2

The Navy would conduct a bioventing treatability study to determine the potential effectiveness of bioventing. If the results showed that bioventing could effectively treat vadose zone soils and achieve the soil RAOs at Area 31, the Navy would fully implement bioventing near the oil/water separator.

If bioventing were fully implemented, system performance would be periodically evaluated. Typically, this is accomplished through respirometry testing, in which biological activity is measured by analyzing soil gases for oxygen uptake and carbon dioxide generation. Shutdown of the bioventing system would occur when the majority of the vadose zone petroleum has degraded and significant biological activity is no longer present.

No active remediation of COCs dissolved in groundwater is included in this alternative. Because this alternative would result in some remaining exceedances of cleanup levels in soil and groundwater, a periodic review of the environmental data would be required no less frequently than every 5 years.

Estimated costs for Alternative 3 are the following:

Capital cost:	\$350,000
Present value O&M costs:	\$242,000
Total present worth:	\$592,000

9.3.4 Alternative 4—Soil Excavation and Removal

Alternative 4 features excavation of contaminated soil and ash piles to attempt to achieve state cleanup levels, eliminate potential ecological risks posed by the surface soil and ash, and reduce future risks posed by organic chemicals in the subsurface soil and groundwater. These actions would remove the majority of the known sources of groundwater contamination. This alternative also includes the removal of the oil/water separator, the implementation of institutional controls, and groundwater monitoring as described for Alternative 2.

The soil removal action would include the top 2 feet of contaminated surface soils, the ash piles, and subsurface soil at the oil/water separator. The subsurface soils would be excavated from the contaminated zone adjacent to and below the oil/water separator. The excavation would include the full areal extent of the petroleum-contaminated vadose zone and would extend down to and several feet below the water table. Product that floats on the groundwater at the bottom of the excavation pit would be skimmed and containerized for off-site treatment or recycling; treatment and recycling of product would be implemented as discussed for Alternative 2.

The excavated soils and ash would be tested and treated off site, as needed, to comply with state and federal regulations for land disposal. Depending on test results, the soil and ash would be disposed of at the Area 6 landfill (on site) or at a permitted landfill (off site).

In summary, this alternative would include the following actions:

- Removal of the ash piles
- Removal of contaminated surface soils
- Removal of the oil/water separator
- Removal of contaminated soil around the oil/water separator down to the water table, and skimming of floating petroleum product from the bottom of the excavation pit
- Treatment/disposal of skimmed product and excavated soil at permitted off-site facilities
- Institutional controls as described for Alternative 2
- Groundwater monitoring as described for Alternative 2

No active remediation of COCs dissolved in groundwater is included in this alternative. Because this alternative would result in some remaining exceedances of cleanup levels in soil and groundwater, a periodic review of the environmental data would be required no less frequently than every 5 years.

Estimated costs for Alternative 4 are the following, assuming 5 years of operation and a 5 percent discount factor:

Capital cost:	$5,091,000
Present value O&M costs:	$67,000
Total present worth:	$5,158,000

These costs assume disposal of excavated soils at a RCRA Subtitle C hazardous waste landfill. This is a conservative assumption; a RCRA Subtitle D solid waste landfill may be able to accept the excavated soils at a lower cost.

10.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

The EPA has established nine criteria for the evaluation of remedial alternatives:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

The following sections summarize the detailed evaluation of alternatives for each area in regard to the nine evaluation criteria.

10.1 AREA 1

Each remedial alternative for Area 1 is discussed in relation to the EPA evaluation criteria in the following subsections.

10.1.1 Overall Protection of Human Health and the Environment

Under Alternative 1, long-term protection of human health and the environment would not be ensured if the site is disturbed by future development. Also, although it is believed that COCs found in groundwater are not affecting the marine environment, Alternative 1 includes no further sampling or monitoring to verify this.

Alternative 2 would provide overall protection of human health and the environment by preventing future disturbance of the landfill, protecting the existing wetlands from future development, and confirming that COCs in groundwater do not adversely affect the marine environment.

Alternative 3 would be most protective of human health by eliminating the potential for human contact with COCs in the landfill contents. The cap and seawall considered under Alternative 3 would provide overall protection of the environment by reducing the potential for contaminant transport from the landfill. However, the cap would cause destruction of the wetlands present on top of the landfill. Wetlands are known to remove contaminants, and the loss of the wetland would increase contaminant transport to the straits as a result of storm drainage presently entering the wetland.

10.1.2 Compliance With Applicable or Relevant and Appropriate Requirements

COCs in soil exceed state cleanup levels under MTCA. COCs detected in groundwater exceed marine water quality standards for protection of the environment (WAC 173-201A and the Federal Clean Water Act). However, it is not known whether these exceedances occur at the point of compliance (i.e., the area where groundwater discharges to marine water).

Alternative 1 would not include cleanup actions or provide institutional controls to prevent human exposures to COCs remaining on site, and it would not include groundwater monitoring to determine whether surface water ARARs are exceeded. Because Alternative 1 would not protect human health and the environment and would not comply with ARARs, it is not considered or discussed further under the remaining evaluation criteria.

Alternatives 2 and 3 would comply with state and federal ARARs. Compliance with state cleanup regulations would be achieved through the institutional controls, monitoring, and containment measures proposed in Alternatives 2 and 3.

10.1.3 Long-Term Effectiveness and Permanence

Alternative 2 would be effective in the long term by preventing future development that could disturb the landfill and possibly mobilize COCs. The existing wetlands would continue to remove COCs from surface water, and long-term reductions in concentrations of COCs in soil, sediments, and groundwater are expected to occur through natural attenuation mechanisms.

Alternative 3 would provide long-term protection against disturbance of the landfill, but continual maintenance of the cap would be necessary. Long-term negative effects are possible as a result of the destruction of the wetlands caused by cap construction.

10.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives 2 and 3 do not include a treatment component.

10.1.5 Short-Term Effectiveness

No short-term risks are associated with Alternative 2. RAOs would be achieved in a short timeframe via implementation of institutional controls and monitoring.

Under Alternative 3, short-term risks to construction workers would be minimized by standard health and safety precautions. Construction would pose potential risks to wildlife and could cause sediment transport to the environment. Cap construction would take approximately 6 months.

10.1.6 Implementability

Technically, Alternatives 2 and 3 are readily implementable. However, the wetlands destruction and shoreline modification included in Alternative 3 could make this alternative difficult to implement administratively.

10.1.7 Cost

The estimated present worth cost of Alternative 2 is $134,000. The estimated present worth cost of Alternative 3 is $2,191,000.

The cost estimates were prepared using costing techniques that typically achieve an accuracy of +50 percent to -30 percent for a specified scope of actions. Additional uncertainty in the costs is introduced by variations in the volumes and other quantities assumed for the estimates.

10.1.8 State Acceptance

Ecology has been briefed on the remedial investigations, feasibility studies, and the proposed plan and concurs with the selected remedies at OU 5.

10.1.9 Community Acceptance

The Restoration Advisory Board has been involved in the review and comment process of all project documents leading to this ROD. On October 24, 1995, the Navy held an open house and public meeting to discuss the proposed plan for final action at OU 5. The public comment period extended from October 10 to November 9, 1995. No public comments were received.

10.2 AREA 52

At Area 52, the range of response actions is limited to no action or a collection system to remove floating petroleum product from groundwater. As discussed in Section 9, the results of the treatability study have shown that oil skimming without groundwater extraction is the only practical way to remove the floating petroleum product. Accordingly, only two alternatives were developed—the no-action alternative and oil skimming combined with institutional controls.

Each remedial alternative for Area 52 is discussed in relation to the EPA evaluation criteria in the following subsections.

10.2.1 Overall Protection of Human Health and the Environment

Under Alternative 1, long-term protection of human health and the environment would not be ensured if the site is disturbed by future development. Also, although it is believed that COCs found in groundwater are not affecting the marine environment, Alternative 1 includes no further sampling or monitoring to verify this.

Alternative 2 would provide overall protection of human health and the environment by preventing future disturbance of subsurface soils, removing the floating petroleum product, and ensuring that COCs in groundwater do not adversely affect the marine environment.

10.2.2 Compliance With Applicable or Relevant and Appropriate Requirements

Petroleum in soil exceeds state cleanup levels under MTCA. COCs detected in groundwater exceed marine water quality standards for protection of the environment (WAC 173-201A and the Federal Clean Water Act). However, it is not known whether these exceedances occur at the point of compliance (i.e., the mixing zone where groundwater discharges to marine water).

Alternative 1 would not include cleanup actions or provide institutional controls to prevent human exposures to COCs remaining on site and would not include groundwater monitoring to determine whether surface water ARARs are exceeded. Because Alternative 1 would not protect human health and the environment and would not comply with ARARs, it is not considered or discussed further under the remaining evaluation criteria.

Alternative 2 would comply with state and federal ARARs. Compliance with state cleanup levels would be achieved through the institutional controls and monitoring proposed in Alternative 2.

10.2.3 Long-Term Effectiveness and Permanence

Alternative 2 would be effective in the long term by permanently removing the floating petroleum product and by preventing future construction or development that could cause exposure to residual petroleum in subsurface soils. Long-term reductions in concentrations of petroleum and related COCs in soil and groundwater are expected to occur through natural attenuation mechanisms.

10.2.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternative 2 includes treatment by recycling of the floating petroleum product recovered from the site. Recycling would return the petroleum to beneficial re-use, permanently reducing its toxicity, mobility, and volume in the environment.

10.2.5 Short-Term Effectiveness

Alternative 2 would not cause significant short-term risks during the construction or operation of the recovery system. It would achieve the RAOs in a short timeframe by implementing institutional controls to prevent potential exposures and through monitoring. Recovery of the floating petroleum product is expected to take several months or years. Therefore, numeric cleanup goals for soil and groundwater are not expected to be achieved for several years.

10.2.6 Implementability

Alternative 2 is readily implementable.

10.2.7 Cost

The estimated present worth cost of Alternative 2 is $213,000.

The cost estimates were prepared using costing techniques that typically achieve an accuracy of +50 percent to -30 percent for a specified scope of actions. Additional uncertainty in the costs is introduced by variations in the volumes and other quantities assumed for the estimates.

10.2.8 State Acceptance

Ecology has been briefed on the remedial investigations, feasibility studies, and the proposed plan and concurs with the selected remedies at OU 5.

10.2.9 Community Acceptance

The RAB has been involved in the review and comment process of all project documents leading to this ROD. On October 24, 1995, the Navy held an open house and public meeting to discuss the proposed plan for final action at OU 5. The public comment period extended from October 10 to November 9, 1995. No public comments were received.

10.3 AREA 31

Each remedial alternative for Area 31 is discussed in relation to the EPA evaluation criteria in the following subsections.

10.3.1 Overall Protection of Human Health and the Environment

Alternative 1 includes no measures to prevent future human health risks posed by COCs in groundwater or to prevent the spread of COCs in groundwater. Alternative 1, therefore, would not protect human health. The only potential ecological risk identified for Area 31 was to small mammals; animals higher on the food chain were not identified as an ecological risk. Therefore, Alternative 1 would be protective of the environment.

Alternatives 2 and 3 would provide overall protection of human health and the environment by preventing human exposures to COCs in soil and groundwater, and by removing and treating the largest sources of COCs that may cause contamination to spread in groundwater.

Alternative 4 would be most protective of human health and the environment. Under Alternative 4, most of the known contamination in surface soil and subsurface soil would be permanently removed from the site, thereby preventing human exposures and eliminating the potential ecological risks to small mammals.

10.3.2 Compliance With Applicable or Relevant and Appropriate Requirements

COCs in soil and groundwater exceed state cleanup levels under MTCA. Alternative 1 includes no actions to address these exceedances or prevent exposures and, therefore, would not comply with ARARs. Because Alternative 1 would not protect human health and the environment and would not comply with ARARs, it is not considered or discussed further under the remaining evaluation criteria.

Alternatives 2, 3, and 4 would comply with state and federal ARARs. However, each of these alternatives would result in some remaining exceedances of cleanup levels on site. These exceedances would be addressed through institutional controls and monitoring to assess the effectiveness of the source reduction actions in controlling the spread of COCs and possibly accelerating their natural attenuation.

10.3.3 Long-Term Effectiveness and Permanence

Alternatives 2, 3, and 4 would each be effective in the long term in preventing the spread of COCs in groundwater and preventing human exposures through institutional controls. Alternatives 2, 3, and 4 would each permanently remove the oil/water separator and the petroleum floating on groundwater, which are the largest sources of contamination. Alternative 3 would provide additional effectiveness over Alternative 2 by permanently destroying petroleum hydrocarbons present in the vadose zone. Alternative 4 would have the greatest long-term effectiveness, because it would permanently remove contaminated surface soil, subsurface soil, and floating petroleum product. Natural attenuation will occur in Alternatives 2 and 3 but may take a long time and may not be as effective as Alternative 4.

10.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives 2, 3, and 4 each include treatment (recycling or incineration) of the floating petroleum product recovered from the site. Recycling would allow beneficial re-use of the petroleum, whereas incineration would permanently destroy the petroleum. Alternative 3 provides additional treatment of vadose zone soils by bioventing, which would permanently destroy the residual petroleum in the vadose zone. Alternative 4 would include treatment of excavated soil to reduce the mobility of contaminants, but the treatment would be conducted only if required prior to landfilling the soil.

10.3.5 Short-Term Effectiveness

None of the alternatives is expected to cause significant short-term risks to the nearby private residences, workers, or environment during remediation because the actions involve common remedial construction activities that are readily controlled.

Alternative 4 has the greatest potential for short-term impacts as a result of construction because it involves deeper and more extensive excavation (about 20 feet down to the water table at the oil/water separator) than Alternatives 2 and 3. Proper system design will minimize or eliminate vapor emissions from the bioventing process.

Each alternative would achieve RAOs in a short timeframe via implementation of institutional controls that would prevent the exposures of concern. No alternative is expected to attain groundwater numeric cleanup levels in a short timeframe because residual contamination will be left at the site in all the alternatives. No alternative includes actions for active remediation of COCs dissolved in groundwater. Alternatives 2 and 3 each involve excavation and disposal of some soil near the oil/water separator, as needed to remove the oil/water separator. Remedial goals for soil would be quickly met in those areas where soil is to be excavated for off-site disposal; this applies most particularly to Alternative 4, which would use soil removal as the principal means to eliminate most of the contamination at the site. Also, under Alternative 4, remedial goals for petroleum in groundwater would be achieved in a short timeframe, although some dissolved COCs may persist for months or years. The estimated period of operation is 5 years or less for both the oil skimming and bioventing systems.

10.3.6 Implementability

There are no major differences among the three alternatives in terms of difficulty of implementation that would significantly favor one alternative over another. Each alternative would use common, readily available equipment and construction techniques.

10.3.7 Cost

The estimated present worth cost of Alternative 2 is $257,000. The estimated present worth cost of Alternative 3 is $592,000. The estimated present worth cost of Alternative 4 is $5,158,000.

The cost estimates were prepared using costing techniques that typically achieve an accuracy of +50 percent to -30 percent for a specified scope of actions. Additional uncertainty in the costs is introduced by variations in the volumes and other quantities assumed for the estimates.

10.3.8 State Acceptance

Ecology has been briefed on the remedial investigations, feasibility studies, and the proposed plan and concurs with the selected remedies at OU 5.

10.3.9 Community Acceptance

The RAB has been involved in the review and comment process of all project documents leading to this ROD. On October 24, 1995, the Navy held an open house and public meeting to discuss the proposed plan for final action at OU 5. The public comment period extended from October 10 to November 9, 1995. No public comments were received.

11.0 THE SELECTED REMEDY

11.1 AREA 1

The Navy has chosen Alternative 2 (limited action—institutional controls and monitoring) as the selected remedy at Area 1. Alternative 2 is protective of human health and the environment and provides the best overall effectiveness proportional to its cost. The institutional controls will prevent potential future human exposure to landfill contents or groundwater by preventing future development that may disturb the landfill and preventing the installation of drinking water wells. The environmental monitoring will meet the RAO of determining compliance with water quality standards for marine water at the point where groundwater discharges to marine water. The major components of the selected remedy are discussed in the following paragraphs.

To prevent residential development or the installation of drinking water wells, land-use restrictions will be entered into the installation restoration site database that is part of the NAS Whidbey Island planning and management model. These restrictions will include special requirements for any other construction that may disturb the landfill, including health and safety plans, environmental protection plans, and waste management plans. The Navy will implement these restrictions. In the event of property transfer, restrictive covenants on the property will be recorded with the Island County register of deeds. The covenants will be binding on the owner's successors and assignees and will place limiting conditions on property conveyance, prohibit well construction except for monitoring purposes, and restrict land use and construction activity that would disturb the landfill. These restrictions will apply to the landfill plus an appropriate buffer zone. Covenants will also require notice to the EPA, Ecology, or their designees of any intent to transfer interest, modify its land use, or implement construction activity; and agency approvals will be required for such actions.

Continued use of existing security measures will control physical access to Area 1 by the general public.

An environmental monitoring program will include groundwater sampling and biological surveys of the beach. In the 1st year, the two inland monitoring wells (MW-18 and MW-103) will be resampled one time for cyanide, and up to six intertidal groundwater samples will be collected from seeps along the shoreline. The intertidal seep samples will be analyzed for total and dissolved inorganics, cyanide, VOCs, and SVOCs to determine compliance with surface water cleanup levels. The surface water cleanup levels are shown in Table 12. The point of compliance for obtaining these cleanup levels is in the seeps along the shoreline. If the results of the intertidal groundwater sampling indicate compliance with surface water cleanup levels, the sampling will be terminated. Visual inspections of the physical condition of the landfill bluff will be conducted annually for the first 5 years and the results documented.

If the results of the 1st year intertidal groundwater sampling indicate that surface water cleanup levels are not met in the intertidal groundwater seep samples, the following monitoring program will be instituted: A biological survey of the intertidal zone will be conducted in the 2nd year. Up to six intertidal groundwater samples will be collected annually from seeps along the shoreline, beginning in the 2nd year. The intertidal seep samples will be analyzed for total and dissolved inorganics, cyanide, VOCs, and SVOCs to determine compliance with surface water cleanup levels. After the 1st year of monitoring, the Navy and the EPA will consider limiting the chemical analyses in subsequent years to those chemicals detected during the 1st year. If the results of the intertidal groundwater seep sampling indicate compliance with surface water cleanup levels for 2 consecutive years, the annual sampling will be terminated. If compliance with surface water cleanup levels has not been attained for 2 consecutive years by the 5th year, a biological survey of the intertidal zone will be conducted. Regardless of the sampling results, visual inspections of the physical condition of the landfill bluff will be conducted annually for the first 5 years, and the results documented.

A periodic review of the data will be conducted no less frequently than every 5 years. At the 5-year review, all data will be evaluated by the EPA and the Navy to jointly assess protection of ecological receptors in the marine environment. The environmental data will be used to assess the need for further action.

11.2 AREA 52

The Navy has chosen Alternative 2 (oil skimming) as the selected remedy at Area 52. Since the only other alternative is no action, Alternative 2 is considered more protective for a reasonable cost, instead of taking no action. Institutional controls will limit human exposure to subsurface soil containing petroleum above cleanup levels and prevent human exposure to COC in groundwater above cleanup levels. The environmental monitoring will meet the RAO of determining compliance with water quality standards for marine water at the point where groundwater discharges to marine water. Removal of free product will meet the RAO of preventing the migration of floating petroleum product from groundwater to marine surface water. The major components of the selected remedy are discussed in the following paragraphs.

The existing monitoring wells that are screened across the water table surface will be used as collection points for removal of floating petroleum product. Up to five additional monitoring/collection wells will be installed to provide additional coverage near the Jet Engine Test Cell and downgradient, where the plume is expected to migrate. The exact number and locations of the wells will be determined in the remedial design. The wells will operate with skimming devices that collect floating petroleum product and prevent the collection of groundwater. The collected oil will be containerized for transport to an off-site recycling or treatment facility. The collected oil will be sampled and analyzed to determine appropriate treatment and recycling requirements. If recycling is not possible, then the collected oil will be treated and/or disposed of in accordance with state and federal regulations. The skimming wells will be operated until it becomes impractical to recover significant amounts of oil.

As a precautionary action, the existing 6-inch-diameter drywell at Area 52 will be excavated, and the excavation will be backfilled with borrow soils. No confirmation sampling will be conducted for the drywell removal.

To prevent residential development or the installation of drinking water wells, land-use restrictions will be entered into the installation restoration site database that is part of the NAS Whidbey Island planning and management model. These restrictions will include special requirements for any other construction that may disturb contaminated soil, including health and safety plans, environmental protection plans, and waste management plans. The Navy will implement these restrictions. In the event of property transfer, restrictive covenants on the property will be recorded with the Island County register of deeds. The covenants will be binding on the owner's successors and assignees and will place limiting conditions on property conveyance, prohibit well construction except for monitoring purposes, and restrict land use and construction activity that would disturb the site. These restrictions will apply to the site plus an appropriate buffer zone. Covenants will also require notice to the EPA, Ecology, or their designees of any intent contamination and stopping the spread of contaminants in groundwater. Once these sources of contamination are removed, natural attenuation is expected to slowly reduce contaminant concentrations in groundwater. In the meantime, institutional controls will meet the RAO of preventing human exposure to COCs in groundwater. The major components of the selected remedy are discussed in the following paragraphs.

To prevent residential development or the installation of drinking water wells, land-use restrictions will be entered into the installation restoration site database that is part of the NAS Whidbey Island planning and management model. These restrictions will include special requirements for any other construction that may disturb contaminated soil, including health and safety plans, environmental protection plans, and waste management plans. The area covered by the land-use restrictions includes the portion of the site where the UST was removed. Installation of drinking water wells would be prohibited over the area where site-related contaminant levels in groundwater exceed cleanup levels. The Navy will implement the restrictions. In the event of property transfer, covenants on the property will be recorded with the Island County register of deeds. The covenants will be binding on the owner's successors and assignees and will place limiting conditions on property conveyance, prohibit well construction except for monitoring purposes, and restrict land use and construction activity that would disturb subsurface soil. Covenants will also require notice to the EPA, Ecology, or their designees of any intent to transfer interest, modify its land use, or implement construction activity; and they will require agency approvals for such actions.

Oil skimming wells will be installed within the zone in which floating petroleum product is present on the groundwater. The wells will operate with skimming devices that collect oil (liquid-phase hydrocarbons) and prevent the collection of groundwater. The collected oil will be containerized for transport to an off-site recycling or treatment facility. The collected oil will be sampled and analyzed to determine appropriate treatment and recycling requirements. If recycling is not possible, then the collected oil will be treated and/or disposed of in accordance with state and federal regulations. The skimming wells will be operated until it becomes impractical to recover significant amounts of oil.

The oil/water separator will be excavated, and any associated piping will be permanently capped or removed. Any liquids and sludges found in the tank, along with any rinsates, will be removed, designated, and disposed. The empty tank will be cleaned and decontaminated. The cleaned tank will be sent off site, either for recycling as scrap metal or for disposal in an RCRA solid waste (Subtitle D) landfill. The oil/water separator is not considered an UST. Petroleum-contaminated soil excavated during to transfer interest, modify its land use, or implement construction activity; and agency approvals will be required for such actions.

Quarterly monitoring of the thickness of the floating petroleum product will be conducted while skimming is occurring. The measurements of petroleum product will be timed to coincide with high and low seasonal water levels.

An environmental monitoring program will include intertidal groundwater seep sampling and biological surveys of the beach. Intertidal groundwater seep samples will be collected biannually, in years 1, 3, and 5 following the signing of the ROD. In each sampling event, up to six intertidal groundwater samples will be collected from seeps along the shoreline and analyzed for VOCs, SVOCs, and TPH to determine compliance with surface water cleanup levels. After the 1st year of monitoring, the Navy and the EPA will consider limiting chemical analyses in subsequent years to those chemicals detected during the 1st year. The surface water cleanup levels are shown in Table 13. The point of compliance for attaining these cleanup levels is in the seeps along the shoreline. Biological surveys of the intertidal zone will be conducted in years 2 and 5 following the signing of the ROD.

An environmental protection plan will be developed by the Navy to ensure that contaminant transport or human exposures do not occur as a result of remediation activities and that proper waste handling and disposal techniques are used during implementation of this remedy. A periodic review of the monitoring data will be conducted no less frequently than every 5 years. At the 5-year review, all data will be evaluated by the EPA and the Navy to jointly evaluate the effectiveness of the selected remedy and assess the protection of ecological receptors in the marine environment.

11.3 AREA 31

The Navy has chosen Alternative 3 (bioventing and oil skimming) as the selected remedy at Area 31. Alternative 3 is protective of human health and the environment and provides the best overall effectiveness proportional to its cost. The institutional controls will limit human exposure to surface soil and subsurface soil and prevent exposure to groundwater containing COCs above cleanup levels. The area covered by the institutional controls includes the portion of the site where the UST was removed. The oil skimming, oil/water separator removal, and bioventing actions will meet the RAOs of reducing the sources of petroleum hydrocarbons in soil that may cause groundwater removal of the oil/water separator will be backfilled into the excavation. Confirmation samples will not be collected from the excavated soil or the limits of excavation.

No further remedial action will be conducted at the burn pad or the location of the former UST. The land use restrictions discussed above will include these areas.

The ash piles at Area 31 will be removed by the Navy and disposed of in accordance with state and federal regulations. No confirmation sampling will be conducted for the ash pile removal. In the event the drainage ditch sediments near sampling location SD-12 are removed, the material will be characterized and disposed of in accordance with state and federal regulations.

A groundwater monitoring program will be conducted to verify that petroleum and other COCs in groundwater are not migrating and that contaminants have naturally attenuated before removing or redefining institutional control boundaries. Samples will be collected annually from up to four monitoring wells, using low-flow sampling techniques. In the first 4 years of groundwater monitoring, samples will be collected near the oil/water separator and analyzed for TPH. If after a suitable period of time the monitoring results indicate that TPH in groundwater is not migrating, the yearly monitoring will be terminated. In the 5th year, groundwater samples will be collected throughout the groundwater plume and analyzed for TPH, VOCs, and manganese.

The Navy will conduct a bioventing treatability study to determine the potential effectiveness of bioventing. If the results show that bioventing could effectively treat vadose zone soils and achieve the soil RAOs at Area 31, the Navy will fully implement bioventing near the oil/water separator. If bioventing is fully implemented, appropriate health and safety measures will be followed, including the possibility of an emissions offgas monitoring program to verify that air quality standards are not exceeded. System performance will be periodically evaluated. Shutdown of the bioventing system will occur when significant biological activity is no longer present.

An environmental protection plan will be developed to ensure that contaminant transport or human exposures do not occur as a result of remediation activities and that proper waste handling and disposal techniques are used during implementation of this remedy.

Exceedances of the groundwater cleanup levels in some wells are expected to persist on site for some time. These exceedances will be addressed through institutional controls to prevent groundwater use. The effectiveness of the remedy in achieving the groundwater RAOs will be evaluated primarily in regard to preventing the spread of

COCs at concentrations above the groundwater cleanup levels. A periodic review of the monitoring data will be conducted no less frequently than every 5 years. At the 5-year review, all data will be evaluated by the EPA and Navy to jointly assess the effectiveness of the selected remedy.

12.0 STATUTORY DETERMINATIONS

Under CERCLA Section 121, selected remedies must be protective of human health and the environment, comply with ARARs, be cost-effective, and use permanent solutions and alternative treatment technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that use treatment that significantly reduces volume, toxicity, or mobility of hazardous wastes as their principal element. The selected remedies for OU 5 are discussed in terms of these statutory requirements in this section.

12.1 AREA 1

12.1.1 Protection of Human Health and the Environment

The selected remedy for Area 1 will protect human health and the environment through institutional controls that will prevent future disturbance of the landfill and protect the existing wetlands from future development. Monitoring will evaluate whether COCs in groundwater are adversely affecting the marine environment.

12.1.2 Compliance With ARARs

The selected remedy for Area 1 will comply with federal and state ARARs that have been identified. No waiver for any ARAR is being sought or invoked for any component of the selected remedy. The ARARs identified for Area 1 are discussed in the following subsections.

Chemical-Specific ARARs

State of Washington Hazardous Waste Cleanup—Model Toxics Control Act (MTCA; WAC 173-340). These regulations are applicable to setting the cleanup standards for soil and groundwater discharges to surface water. They are relevant and appropriate to the sediments in the wetlands.

Ambient Water Quality Criteria (Clean Water Act Section 304; *Quality Criteria for Water* [U.S. EPA 1986b]). Water quality criteria are relevant and appropriate for surface waters and groundwater discharges to surface water for the protection of human health and aquatic life.

Water Quality Standards (Clean Water Act Section 303; 40 CFR 131; WAC 173-201A). Water quality standards are relevant and appropriate for surface water and groundwater discharges to surface water for the protection of aquatic life.

State of Washington Water Quality Standards for Surface Waters (WAC 173-201A). State water quality standards are applicable for the protection of aquatic life in fresh and marine surface waters. These state standards enforce the requirements of the Clean Water Act. They are relevant and appropriate to the discharge of groundwater to surface water.

Location-Specific ARARs

Federal Executive Order 11990 (40 CFR Part 6, Appendix A). This requirement is applicable to the actions that may affect the wetlands at Area 1. It requires that all possible actions be taken to avoid harming the wetlands.

The Endangered Species Act (16 USC 1531 promulgated by 33 CFR 320-330). This act is relevant and appropriate to Ault Field in general because several birds and plants listed as sensitive or threatened species are known to inhabit the base. However, the actions of the selected remedy at Area 1 will not affect critical habitat of these species.

State Minimum Standards for the Construction and Maintenance of Wells (WAC 173-160). These standards are applicable and prohibit construction of drinking water wells within 1,000 feet of a solid waste landfill.

Action-Specific ARARs

State Minimum Standards for the Construction and Maintenance of Wells (WAC 173-160). These standards are applicable for construction, testing, and abandonment of resource protection wells, such as monitoring wells.

12.1.3 Cost Effectiveness

The selected remedy for Area 1 is cost effective because it has been determined to provide overall effectiveness proportional to its cost, with an estimated present worth cost of $134,000. The capping alternative considered for Area 1 would cost approximately 16 times as much as the selected remedy and may have a net negative impact on the environment due to destruction of wetlands (which are located on top of the landfill) and loss of habitat. Therefore, the selected remedy represents a reasonable value for the money that will be spent.

12.1.4 Utilization of Permanent Solutions and Treatment Technologies to the Maximum Extent Practicable

The selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost-effective manner for Area 1. It is protective of human health and the environment, complies with ARARs, and provides the best balance of tradeoffs in terms of long-term effectiveness, permanence, short-term effectiveness, implementability, cost, and reductions in toxicity, mobility, or volume achieved through treatment. The selected remedy meets the statutory requirement to use permanent solutions to the maximum extent practicable. However, treatment was not found to be practicable at Area 1 because of the heterogeneous nature of the landfill and the relatively low concentrations of chemicals.

12.1.5 Preference for Treatment as a Principal Element

The selected remedy for Area 1 does not satisfy the preference for treatment to address the principal threats posed by the site. As explained above, treatment was not found to be practicable at Area 1.

12.2 AREA 52

12.2.1 Protection of Human Health and the Environment

The selected remedy for Area 52 will protect human health and the environment through institutional controls that will prevent future exposures to petroleum-contaminated subsurface soils and via removal and treatment of the floating petroleum product that is the largest source of contamination. The potential for future discharge of petroleum or other COCs to marine surface water will be reduced, and monitoring will ensure that COCs in groundwater are not adversely affecting the marine environment.

12.2.2 Compliance With ARARs

The selected remedy for Area 52 will comply with federal and state ARARs that have been identified. No waiver of any ARAR is being sought or invoked for any component of the selected remedies. The ARARs identified for Area 52 are discussed in the following sections.

Chemical-Specific ARARs

State of Washington Hazardous Waste Cleanup—Model Toxics Control Act (MTCA; WAC 173-340). These regulations are applicable to setting the cleanup standards for soil and groundwater discharges to surface water.

Ambient Water Quality Criteria (Clean Water Act Section 304; Quality Criteria for Water [U.S. EPA 1986b]). Water quality criteria are relevant and appropriate for surface waters and groundwater discharges to surface water for the protection of human health and aquatic life.

Water Quality Standards (Clean Water Act Section 303; 40 CFR 131; WAC 173-201A). Water quality standards are relevant and appropriate for surface water and groundwater discharge to surface water for the protection of aquatic life.

State of Washington Water Quality Standards for Surface Waters (WAC 173-201A). State water quality standards are applicable for the protection of aquatic life in fresh and marine surface waters. These state standards enforce the requirements of the Clean Water Act. They are relevant and appropriate to the discharge of groundwater to surface water.

Location-Specific ARARs

The Endangered Species Act (16 USC 1531 promulgated by 33 CFR 320-330). This act is relevant and appropriate to Ault Field in general because several birds and plants listed as sensitive or threatened species are known to inhabit the base. However, the actions of the selected remedy at Area 52 will not affect critical habitat of these species.

Federal Coastal Zone Management Act (16 USC 1451). The requirements of this act are applicable to any construction activities at Area 52. Proposed actions must be consistent with the state coastal zone management plan (i.e., Washington's Shoreline Management Act).

Washington Shoreline Management Act (RCW 90.58; WAC 173-14, 16, 22). These regulations are applicable to any construction activity at Area 52. Proposed actions must be consistent with the policies and goals of the state shoreline management program and with the policies and shorelands use designations of the local shoreline master plan. Provisions also apply to wetlands.

State Minimum Standards for the Construction and Maintenance of Wells (WAC 173-160). These standards are applicable and prohibit construction of drinking water wells within 1,000 feet of a solid waste landfill.

Action-Specific ARARs

State Minimum Standards for the Construction and Maintenance of Wells (WAC 173-160). These standards are applicable for construction, testing, and abandonment of resource protection wells, such as monitoring and extraction wells.

State of Washington Dangerous Waste Regulations (WAC 173-303). These regulations specify waste identification, storage, manifest, transport, treatment, and disposal requirements for solid waste that may contain hazardous substances. These requirements are applicable to recovered petroleum generated during remediation of Area 52, if the recovered petroleum cannot be used for its intended purpose.

12.2.3 Cost Effectiveness

The selected remedy for Area 52 is cost effective because it has been determined to provide overall effectiveness proportional to its cost, with an estimated present worth cost of $213,000. The selected remedy is the only alternative that achieves the RAOs for Area 52.

12.2.4 Utilization of Permanent Solutions and Treatment Technologies to the Maximum Extent Practicable

The selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost-effective manner for Area 52. It is protective of human health and the environment, complies with ARARs, and provides the best balance of tradeoffs in terms of long-term effectiveness, permanence, short-term effectiveness, implementability, cost, and reductions in toxicity, mobility, or volume achieved through treatment. Recovering the floating petroleum product will permanently reduce the toxicity, mobility, and volume of the most mobile contaminants at Area 52. The selected remedy meets the statutory requirement to use permanent solutions to the maximum extent practical.

12.2.5 Preference for Treatment as a Principal Element

The selected remedy for Area 52 satisfies the preference for treatment to address the principal threats posed by conditions at the site. Recovery and recycling or treatment of floating petroleum product will permanently remove the most mobile contaminants at Area 52.

12.3 AREA 31

12.3.1 Protection of Human Health and the Environment

The selected remedy for Area 31 will protect human health and the environment through institutional controls that will prevent human exposures to COCs in soil and groundwater, and through the removal and treatment of the largest sources of COCs that may cause contamination to spread in groundwater. Monitoring will ensure that COCs in groundwater are not migrating outside the limits of the institutional controls and that the institutional controls are maintained as long as the risks remain.

12.3.2 Compliance With ARARs

The selected remedy for Area 31 will comply with federal and state ARARs that have been identified. No waiver of any ARAR is being sought or invoked for any component of the selected remedy. The ARARs identified for Area 31 are discussed in the following sections.

Chemical-Specific ARARs

State of Washington Hazardous Waste Cleanup—Model Toxics Control Act (MTCA; WAC 173-340). These regulations are applicable to setting the cleanup standards for soil and groundwater. They are relevant and appropriate to ditch sediments and ash.

Safe Drinking Water Act and National Primary Drinking Water Regulations maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs) (40 CFR 141; 57 FR 31776). MCLs and non-zero MCLGs are relevant and appropriate requirements to setting the cleanup standards for groundwater at Area 31. Requirements will be met by source control and natural attenuation.

Location-Specific ARARs

Endangered Species Act (16 USC 1531 promulgated by 33 CFR 320-330). This act is relevant and appropriate to Ault Field in general because several birds and plants listed as sensitive or threatened species are known to inhabit the base. However, the actions of the selected remedy at Area 31 will not affect critical habitat of these species.

Action-Specific ARARs

State Minimum Standards for the Construction and Maintenance of Wells (WAC 173-160). These standards are applicable for construction, testing, and abandonment of resource protection wells, such as monitoring and extraction wells.

Hazardous Materials Regulations (49 CFR Subchapter C, Parts 171 to 180). These regulations address the movement of hazardous materials on public roadways. If waste generated during the selected remedy is hazardous and must be transported to a treatment or disposal facility, these rules are considered applicable.

Federal Resource Conservation and Recovery Act (40 CFR 261, 262, 263, and 268). These regulations specify waste identification, storage, manifest, transport, treatment, and disposal requirements for hazardous waste. These requirements are applicable to recovered petroleum generated during remediation of Area 31.

State of Washington Dangerous Waste Regulations (WAC 173-303). These regulations specify waste identification, storage, manifest, transport, treatment, and disposal requirements for dangerous waste. These requirements are applicable to recovered petroleum generated during remediation of Area 31.

Federal Clean Air Act General Provisions (40 CFR 52) and Puget Sound Air Pollution Control Authority Regulation 1, Section 9.15. These regulations for the control of fugitive dust during construction activities are applicable to the excavation actions of the selected remedy.

12.3.3 Cost Effectiveness

The selected remedy for Area 31 is cost effective because it has been determined to provide overall effectiveness proportional to its cost, with an estimated present worth cost of $592,000. Each of Alternatives 2, 3, and 4 would achieve the RAOs. The selected remedy (Alternative 3) provides for treatment of a much larger amount of contamination than Alternative 2, at an incrementally larger cost. Although Alternative 4 would address the largest amount of contamination, it would cost roughly eight times as much as the selected remedy. Therefore, the selected remedy represents a reasonable value for the money that will be spent.

12.3.4 Utilization of Permanent Solutions and Treatment Technologies to the Maximum Extent Practicable

The selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost-effective manner for Area 31. It is protective of human health and the environment, complies with ARARs, and provides the best balance of tradeoffs in terms of long-term effectiveness, permanence, short-term effectiveness, implementability, cost, and reductions in toxicity, mobility, or volume achieved through treatment. Recovering and recycling (or incinerating) the floating petroleum product, along with bioventing of vadose zone soils, will permanently reduce the toxicity, mobility, and volume of the most mobile contaminants at Area 31. The selected remedy meets the statutory requirement to use permanent solutions and treatment technologies to the maximum extent practicable.

12.3.5 Preference for Treatment as a Principal Element

The selected remedy for Area 31 satisfies the preference for treatment to address the principal threat posed by conditions at the site. The treatment technologies include recovery of floating petroleum product, recycling or treatment of the petroleum, and bioventing. These technologies will permanently remove the most mobile contaminants at Area 31.

13.0 DOCUMENTATION OF SIGNIFICANT CHANGES

The proposed plan released for public comment in October 1995 discussed remedial action alternatives for the three areas at OU 5 and identified the preferred alternatives. No significant changes to the selected remedies have occurred.

APPENDIX A
Responsiveness Summary

APPENDIX A
RESPONSIVENESS SUMMARY

On October 24, 1995, the Navy held an open house and public meeting to discuss the proposed plan for final action at OU 5. The public comment period extended from October 10 to November 9, 1995. No written or oral public comments were received.

An information repository containing all primary site documents is located at the NAS Whidbey Island Library, Oak Harbor, Washington.